Cranfield University

Jude W. Taunson

Stock index futures in Malaysia:
Does tick size reduction matters?

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Supervisor: Professor Sunil S. Poshakwale

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Abstract

This thesis investigates the impact of tick size reduction on spot index liquidity and in turn on the inter-market pricing relationship between spot and futures indices. Three empirical chapters are presented. The first study investigates the impact on the spot index liquidity in emerging Malaysian capital market. To the best of our knowledge, we are first to investigate this issue. We find higher trading volume following tick size reduction. Further, we find lower mispricing between the spot and futures indices after the reduction. This is an indication that traders benefit from the lower tick sizes. In our second study, the price discovery role of the index futures is assessed. We find that the index futures adjust to equilibrium level ahead of its underlying. Interestingly, the spot index adjusts to equilibrium level at a higher speed in comparison to pre-reduction period. This implies that the lowering of tick sizes facilitates better incorporation of stock specific information. Altogether, the lowering of tick sizes seems to improve index futures price discovery role. In our third paper, we investigate the effectiveness of the index futures as a hedging instrument. We find evidence that the ability of the futures in reducing price risk is greatly enhanced due to the positive impacts of the lower tick sizes.

To my dear parents

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CHAPTER 1

Introduction: background and summary of findings

1.1. The tick size: A background

A Financial Exchange is defined as a place (physical or electronic) where traders gather to trade financial instruments (common stocks, bonds, derivatives amongst others). To name a few, London Stock Exchange (LSE), New York Stock Exchange (NYSE) and Tokyo Stock Exchange (TSE) are some of the world's major stock exchanges. These financial exchanges exist to facilitate the movement of capital between investors and borrowers.

In doing so, financial exchanges must provide liquidity and price discovery. Liquidity is perhaps best defined as the ability to convert stocks into cash at lowest trading costs, while price discovery refers to the ability of the market in finding the equilibrium price. These two functions are inseparably linked because a market that provide the most price discovery tend to be highly liquid and vice versa (O'Hara 2001).

An exchange that performs these two functions well is said to possess the characteristics of a good quality market; i.e., a market that ensures a level playing field for all market participants. Consequently, market quality determines investors' confidence so that investors are more willing to invest in the exchange's listed companies. This in turn attracts issuers to list their securities with them. The exchange thereby obtains greater revenue from listing and transaction fees, and their agents make greater profits.

Thus, it is crucial for exchanges to maintain and continually improve the quality of its market in meeting their clients' needs and meeting the ever-challenging external forces. This is especially true given that markets are increasingly becoming global and competitive. Exchanges around the world have no choice but to compete for new listings and new investors. The inability to compete will result in closure, Nasdaq Europe and Nasdaq Deutschland for example, ceased their operations in 2003 due to the intense competition in the European market.

To foster liquidity and enable price discovery, O'Hara (2001) suggests that exchanges must carefully consider their market design, the trading rules that govern their daily trading operations. Specifically, she suggests that market should be designed by taking into account the types of investors trading and the types of securities traded. In other words, there is no consensus on which market design is the most optimal. Consequently, exchanges around the world continue to strive for the optimal market design that will ensure market quality. This is important because everyone benefits from having a well functioning market.

One of the key features of market design is the tick size, defined as the minimum price that a stock is allowed to change.[1] It determines the price at which investors could execute their trades. For example, a stock with a tick size of 10p and a current price of £1.00, could only moves up (down) in multiple of 10p, hence the price that traders could quote would be £1.10 (90p). This implies that traders may be force to buy (sell) above (below) equilibrium prices (Anshuman & Kalay 1998). Thus, tick size effectively determines the minimum size of the spread, defined as the difference between seller's ask price and buyer's bid price. On one hand, a larger tick may induce larger spreads because the spread would never be lower than the tick size (Harris 2003, p.531). For liquidity demander a large spread means higher trading cost. Also, price discovery will be disrupted because traders would not be able to trade near the equilibrium level if the tick is large (Kurov 2008). On the other hand, a narrow spread lowers profitability and increases the risk of front-running, the risk that a trader may gain priority in the order book simply by offering a relatively better quotation in comparison to a quotation that was previously offered by another trader. As a consequence, liquidity supplier may reduce their supply i.e. market depth.[2] Further, price discovery may be delayed because when the tick is narrower, the number of possible prices at which to trade increases, and this may complicate negotiation process leading to slower speed of execution (Harris 1991).

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[1] Market design features of an exchange include market type (order- and/or quote-driven market), order priority rules, market linkages, market fragmentation and short-selling restrictions, amongst others. Tick size is also known as the minimum price variations/increments and price-steps.

[2] Market depth is defined as the orders 'que' in the book pending for execution based on price-time priority, the longer the 'que' the deeper is the market, usually the best 5 price steps will be displayed.

Table 1.1 below illustrates the trade-off between a large and narrow tick size. In general, the size of tick affects liquidity and price discovery through its effect on trader's profitability (Harris 1999).

Table 1.1: Trade-off between large and small tick size

Tick Size	Liquidity Demander	Liquidity Supplier	Impact on Liquidity
Large	High transaction cost	High profit - willing to supply more liquidity because the risk of front running is lower (high market depth).	Low liquidity due to high transaction cost
Small	Low transaction cost	Low profit - unwilling to supply more liquidity because the risk of front running is higher (low market depth).	Low liquidity due to lower market depth

Tick size (and relative tick size[3]) varies substantially across exchanges and also within exchanges[4]. In some exchanges, for example in the US markets the tick for all stocks over \$1 is \$0.01. However, in Tokyo Stock Exchange, the minimum price increment varies with stock price. For example, the relative tick size for stocks trading in the range of (Japanese Yen) ¥2000 to (Japanese Yen) ¥2295, is between 0.25% to 0.22%, while for stocks trading between (Japanese Yen) ¥3000 to (Japanese Yen) ¥29,990, the relative tick size is between 0.33% to 0.03% (please refer Appendix 1 on page 130). Exchanges around the world, however, have been experimenting with their tick sizes in search for the optimal tick that will ensure high liquidity and price discovery. In particular, there is a trend for exchanges to lower their minimum price increment. We shall discuss the arguments and concerns of this trend in the following section.

1.2. The lowering of tick size: arguments and concerns

During the past two decades or so, it has become a trend for exchanges around the world to reduce their minimum price increments. In the United States, the tick had been reduced from $\$1/8^{th}$ to $\$1/16^{th}$ on 24 June 1997 and again to \$0.01 on 29 January 2001 following the decimalisation exercise. Similarly, in emerging markets such Taiwan and Malaysia, the ticks were reduced on the 1 March 2005 and 3 August 2009, respectively.

[3] Tick size as a percentage of price per share.

[4] See Comerton & Rydge (2006) for an excellent overview of market design in the Asia-Pacific region.

Table 1.2 below lists some other exchanges around the world that had also reduced their minimum price increments.

Table 1.2: Stock exchanges that have lowered their minimum price increments

Stock Exchange	Date
Australia Stock Exchange	04 December 1996
Bursa Securities Berhad	03 August 2009
Hong Kong Stock Exchange	24 July 2006
Jakarta Stock Exchange	03 July 2000
AMEX	29 January 2001
NASDAQ	29 January 2001
NYSE	29 January 2001
Singapore Stock Exchange	18 July 1994
Taiwan Stock Exchange	01 March 2005
Thailand Stock Exchange	05 November 2001
Tokyo Stock Exchange	13 April 1998
Toronto Stock Exchange	29 January 2001

Proponents of a lower tick argue that lower tick improves market liquidity. The reason is that a lower tick would induce a reduction in bid-ask spread due to increased competition between liquidity suppliers. As a result, trading cost decreases which in turn may lead to higher trading volume (Harris 1997). This is especially true if the current tick binds or restricts the stock from reflecting its intrinsic value (Harris 1994). In other words, liquidity demanders benefit from the lower trading cost caused by a lower tick size (Bacidore 1997; Bessembinder 2003; Smith et al. 2006). They further argue that a lower ticks facilitates efficient price discovery (Sugato et al. 2004) because a lower trading cost increases traders' incentives to gather information (Gibson et al. 2003).

Opponents of lower tick size, however, argue that a lower spreads may benefit liquidity demanders at liquidity suppliers' expense (Graham et al. 2003). The lower profitability and higher risk of front-running would adversely affect liquidity suppliers' readiness to provide liquidity (Jones & Lipson 2001). Consequently, trading volume may not increase given that a lower tick also increases the cost of negotiation (Hameed & Terry

1998). Thus, the impact of tick size reduction on the trading volume is not straightforward as it relies on how the demand and supply of liquidity are affected by lower trading costs because of smaller tick sizes. Whether a lower tick results in a higher trading volume is of concern to exchanges because not only will they derive higher revenue from it, but it indicates an improvement in market quality (Angel 2012, p.8).

Given the inconclusive impact of a lower tick size on the trading volume of the constituents stocks that make-up an index, there are also concerns that a lower tick may weaken the relationship between the underlying index and index futures markets. The reason is that spot index volume affects the basis[5] (Roll et al. 2007). The basis in turn determines the reliability and effectiveness of index futures as a price discovery and hedging instrument. The price discovery role of index futures refers to the ability of the market in finding the equilibrium price ahead of the underlying index, while hedging is defined as the ability of the market in reducing price risk. In other words, the price discovery role and hedging effectiveness of index futures depend on the magnitude and stability of the basis (Garbade & Silber 1983; Sutcliffe 2006).

The basis may narrow if the unexpected trading volume in the underlying market following the tick size reduction represents those of arbitrageurs' (Henker & Martens 2005) and as a consequence of better incorporation of firm specific information in the underlying market (Chordia et al. 2008). However, the basis may widen, if the unexpected trading volume represents trade by speculators that causes the index futures to delay in responding to both firm specific and market-wide information (Cummings & Frino 2011). If this is the case, the reliability of index futures as price discovery tool and hedging instrument will be adversely affected.

In this study, we aim to contribute to the literature by addressing the above concerns posed by a lower tick size. Specifically, we examine the impact of a lower tick on spot index trading volume and in turn on the inter-market relationship between the spot and futures in the emerging Malaysian market. Also, we aim to contribute to the literature

[5] In this study, the term basis and mispricing are used interchangeably.

by examining the price discovery role and hedging effectiveness of the index futures given that these two main functions of index futures rely on the strength of the inter-market relationship. Fig. 1.1 below shows the focus of this study.

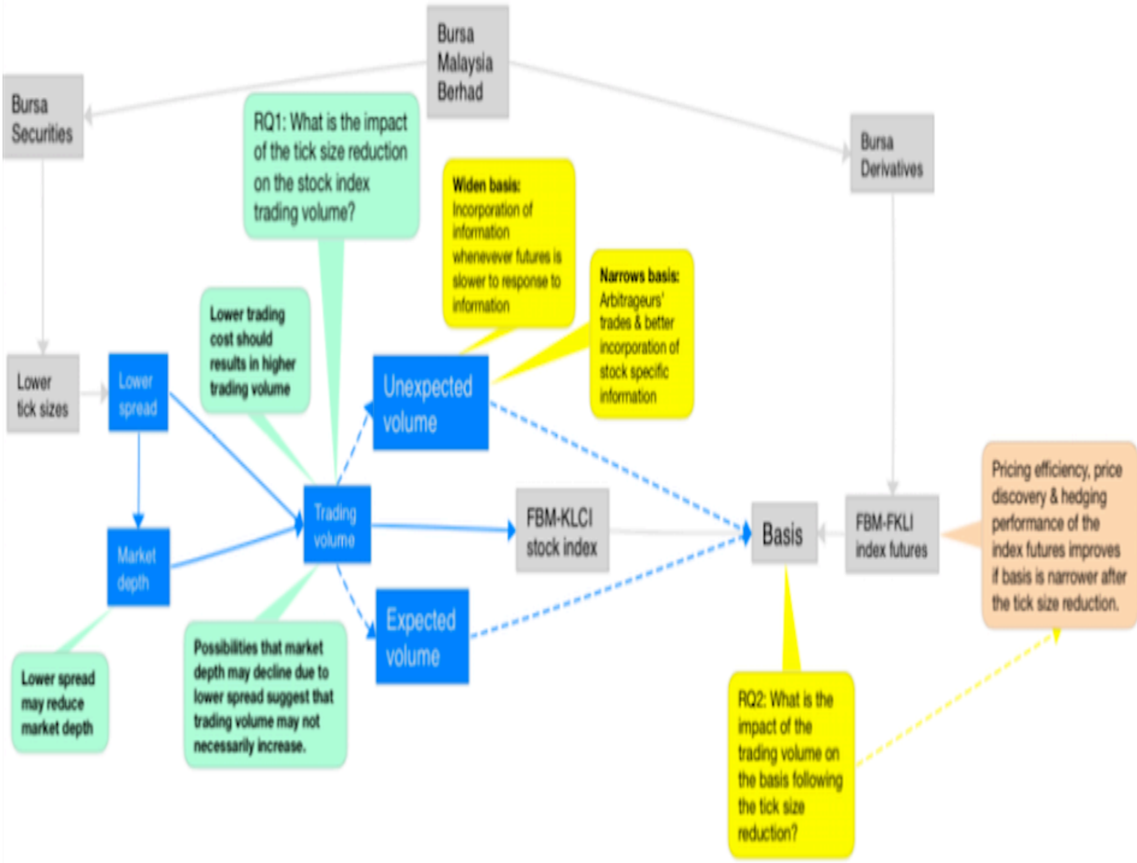

Fig. 1.1: Focus of the study

Malaysian market is chosen due to its distinctive market design in comparison to other markets. In an order driven market such as Bursa Malaysia, the only source of liquidity is the limit order book, which is greatly influenced by the size of the tick due to the order priority rules. In addition, Bursa Malaysia uses a tick structure that varies with price, therefore even higher priced stocks are most likely be constrained by the tick. These suggest that the impact of the tick reduction on liquidity may be larger for Bursa Malaysia. Further, there is little research evidence about the interaction between index futures and stock market in Malaysia. The following section briefly discusses some background on Bursa Malaysia.

1.3. Bursa Malaysia Berhad

Stock trading begun in Malaysia in the 1930s when Singapore Stockbroker's Association was established. In 1937 the association was re-registered as Malayan Stockbroker's Association and subsequently renamed as Malayan Stock Exchange in 1960 with trading floors in Kuala Lumpur and Singapore linked by telephone. Following the withdrawal of Singapore in 1973, the exchange was divided into Kuala Lumpur Stock Exchange (KLSE) and Stock Exchange Limited (SGX). The KLSE became a limited company on 14 Dec 1976 and changed its name to Bursa Malaysia Berhad (BMB) on 14 April 2004 following the demutualisation exercise.[6] BMB is an integrated exchange, it provides, operates and maintain a complete range of exchange-related services including trading, settlement, clearing and depository services (please refer Fig. 1.2).[7]

1.3.1. Capital market masterplan

Following the Asian Financial Crisis in 1997, the Malaysian government initiated a strategic 10-year plan known as Capital Market Masterplan (CMP), and was officially launched by the Malaysian Securities Commissions (SC) in February 2001. The CMP is intended to fortify the financial market and so be in a better position to meet the challenges of regional competition and globalisation.

The four key challenges at hand were to address the lingering effects of the Asian financial crisis in 1997/1998, to meet the demands of the growing economy, to heighten global competition for business and investment, and finally to meet the changing demands on the regulatory framework and authorities (please refer Fig. 1.3). In order to achieve its vision i.e. to be internationally competitive, it is crucial that the Malaysian capital markets addressed these challenges.

[6] Demutualisation led to the conversion of the exchange from an entity limited by the guarantee of its members into a public company limited by shares. On 4 March 2004, the exchange raised Ringgit Malaysia 521 millions ($\simeq$ £105 millions) from its intial public offering (IPO).

[7] The establishment of a single Malaysian exchange by consolidating all existing exchanges i.e. derivatives exchange and offshore financial exchange) was the first recommendation in the Capital Market Masterplan.

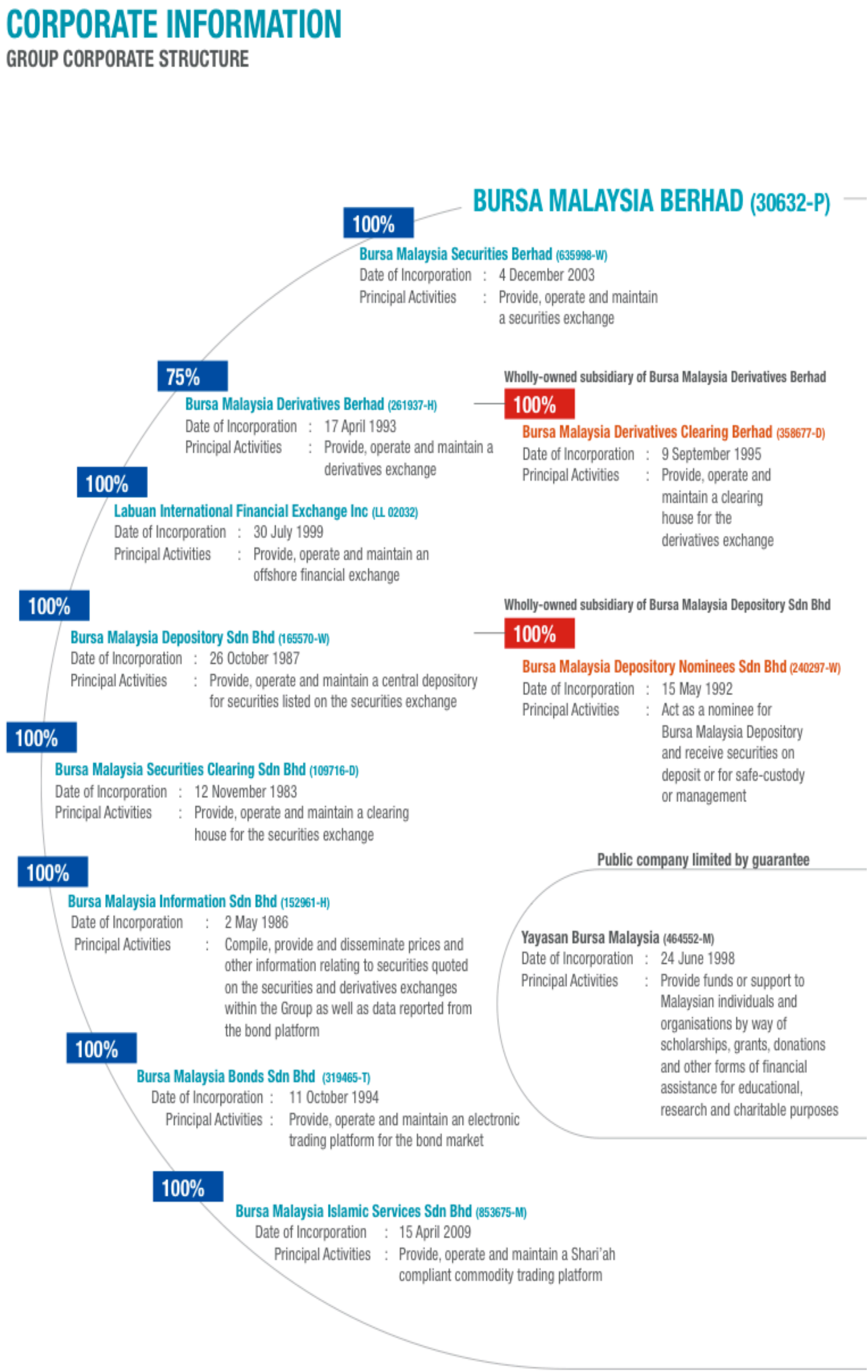

Fig. 1.2: Bursa Malaysia Berhad and its subsidiaries
Source: Bursa Malaysia Annual Report, 2012

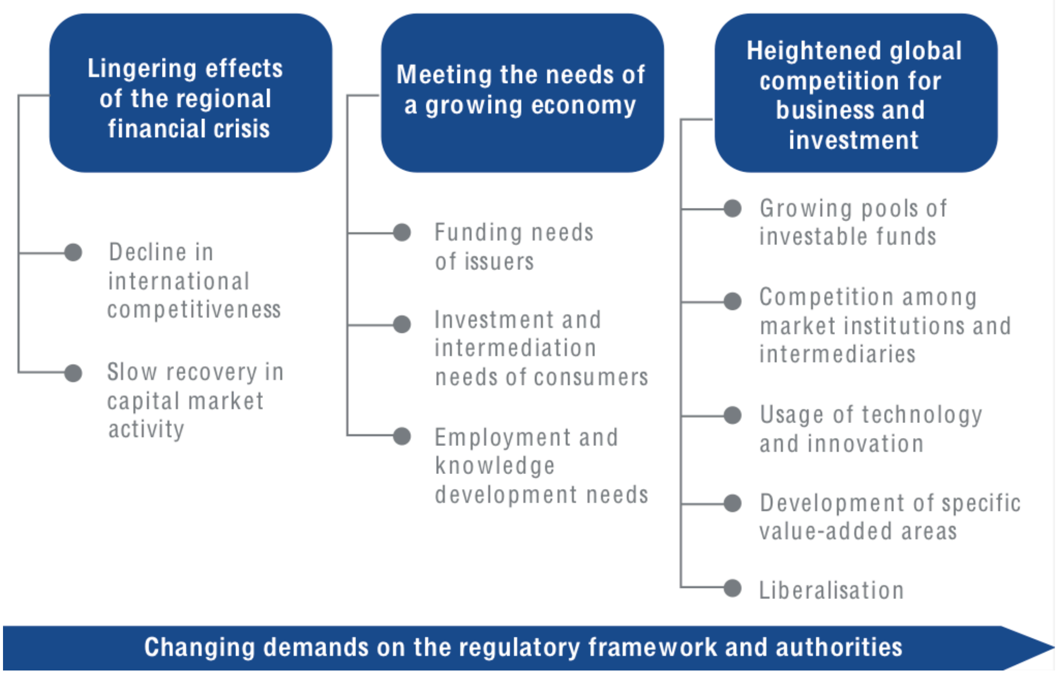

Fig. 1.3: Challenges for the Malaysia capital market

There are 152 recommendations outlined in the CMP to address the challenges above (refer Appendix 2 on page 136). These recommendations have been formulated on the basis of the capital market's vision and objectives with consideration of the trends and challenges the capital market will have to deal over the next 10 years. Moreover, where appropriate, further recommendations will be introduced over the course of the period of the Masterplan to ensure that it is remain relevant. In other words, the Masterplan is a dynamic plan, not static. The CMP covers various segments of the markets. For example, the recommendations from 17 to 32 are directly related to the equity market and from 50 to 64 are for the derivatives market. Bursa Securities and Bursa Derivatives run the equity and derivatives markets, respectively under their parent company.

Table 1.3 below lists some of the recommendations concerning the stock market as outlined in the CMP. One of the key recommendations was to reduce the tick sizes for stocks listed in the Bursa Securities with the objective of promoting liquidity and enhancing price discovery.

Consequently, the tick sizes were reduced on the 3 August 2009. Table 1.4 illustrates the differences between the old tick sizes and the new tick sizes. All stocks listed on the exchange are affected by this reduction. It is also worth noting that the tick size reduction is also effective on the exchange-traded funds (ETFs)[8] as shown in Appendix 3 on page 142.

Table 1.3: Main market design changes in Bursa Securities over the past decade

Date	Description
26th May 2003	Full implementation of smaller board lots of 100 shares each, from 1000 shares per lot previously.
26th June 2006	Launch of FTSE Bursa Malaysia Index Series in collaboration with FTSE Group, the global index provider.
3rd January 2007	Securities borrowing and lending (SBL) and Regulated short-selling (RSS) were reintroduced.
6th July 2009	Kuala Lumpur Composite Index (KLCI) was renamed FTSE Bursa Malaysia KLCI (FBM-KLCI). The index adopted the FTSE's global index methodology which is free-float adjusted, liquidity-screened and calculated on a fifteen second basis.
3rd August 2009	**Reduction of tick size**
3rd August 2009	New one hour trading halt

Source: Bursa Malaysia annual reports

The impact of the tick reduction on liquidity may be larger for an order-driven market such as Bursa Malaysia (Harris 1997). The reason is that the size of the tick determines the cost of obtaining priority in the limit order book, the only source of liquidity.[9] In an order-driven market, traders' orders are arrange by the price-time-public priority rule. This rule states that priority is given to buyers (sellers) who bid (offer) the highest (lowest) price. If however orders are received at the same price, priority is given to traders who first shown their willingness to trade at that price and to public limit orders. In other words, this priority rule is in place to protect public limit traders from front-running by professional traders. However, the tick reduction may instead increase the risk of front-running if the tick is set too small, making it possible for any traders to obtain priority by merely submitting a trivial amount. Traders then may be reluctant to display their orders and/or may switch to market order strategies. Consequently,

[8] The FBM-KLCI exchange traded funds (ETFs) were first listed on 19 July 2007.
[9] Currently, no official market makers operate on Bursa Malaysia Bhd. In contrast, market makers are well established in the highly developed markets (Comerton-Forde & Rydge, 2006).

liquidity and price discovery may not improve as intended. Therefore, it is important for us to examine the impact of the tick reduction on the spot index liquidity and in turn on the strength of relationship between the index futures and its underlying. Also, it is important to examine the price discovery role and hedging effectiveness of the index futures given that these two main functions of index futures rely on the strength of the inter-market relationship.

Table 1.4: New tick sizes for securities

Stock price (Ringgit Malaysia (RM))[a]	Old tick size (sen)	New tick size (sen)
Below 1.00	0.5	0.5
1 to 2.99	1	1
3 to 4.99	2	1
5 to 9.99	5	1
10 to 24.99	10	2
25 to 99.98	25	2
Above 100	50	10

Source: Bursa Malaysia Annual Report 2009

[a]RM1 = 100sen ≈ £0.20

Note: In summary, tick size remain unchanged for stocks trading below RM1 and for stocks trading in the price range of RM1 to RM2.99 i.e. RM0.005 and RM0.01 respectively. For stocks trading in the price range of RM3 to RM4.99 and RM5 to RM9.99, the tick size have been reduced to RM0.01, previously it was RM0.02 and RM0.05 respectively. While stocks trading in the price range of RM10 to RM24.99 and RM25 to RM99.98, the new tick size is RM0.02 reduced from RM0.10 and RM0.25 respectively. Finally, stocks that are trading above RM100 per share, the tick size is reduced from RM0.50 to RM0.10.

In examining the impact of the tick reduction on liquidity, we shall focus on the FBM-KLCI stock index given that the liquidity of the 30 constituent stocks are directly affected by the tick reduction. The FBM-KLCI composite index was first introduced in Malaysia on 4 April 1986 and serves as the barometer of the Malaysian stock market. The constituent stocks are screened for liquidity before and after its inclusion in the index and the index is calculated in real-time for every 15 seconds. The FBM-FKLI index futures derives its value from the underlying stock index FBM-KLCI. As such, we assess the inter-market relationship between the FBM-KLCI spot index and FBM-FKLI index futures taking into account the impact of the tick reduction.

1.3.2. Bursa Derivatives Berhad

Derivatives trading began in Malaysia with the establishment of the Kuala Lumpur Commodity Exchange (KLCE) in October 1980. The KLCE was later renamed the Commodity and Monetary Exchange of Malaysia (COMEX) and in December 2000 merged with the Kuala Lumpur Options and Financial Futures Exchange (KLOFFE) to form the Malaysia Derivatives Exchange (MDEX). MDEX was acquired by Bursa Malaysia in January 2004 and subsequently renamed Bursa Derivatives (BD) following the demutualisation exercise. BMD is the only derivatives exchange in Malaysia, it provides, operates and maintains a futures and options exchange.

Derivatives trading continue to contribute to the group's revenue. In 2013, revenue from derivatives trading improved by 11% to RM70.3 million compared to previous year. The growth in trades was largely attributed to foreign institutions which grew by 32%. Perhaps, this may in part be explained by the strategic alliance between Bursa Malaysia Berhad and Chicago Mercantile Exchange, formed in September 2009, with the specific aim of improving the accessibility to its derivatives offerings globally.[10] On the 20 September 2010, all derivatives products were successfully migrated onto Chicago Mercantile Exchange (CME) Globex®, the electronic platform of CME which enable global traders to access BMD's product electronically.

Futures Industry Association (FIA), in its reports published in 2014 ranked Bursa Derivatives the 39 largest derivatives exchange by volume. The number of contracts traded and/or cleared during the year 2014 was 12,313,490 contracts, an increment of 15.90% from the previous year. The ranking for other derivative exchanges around the world for the year 2014 is shown in Table 1.5 below.

[10] CME holds 25% of the equity stake in Bursa Malaysia Derivatives.

Table 1.5: Exchange rank by volume for the year 2014

Rank	Exchange	Jan-Dec 2014 Volume	Jan-Dec 2013 Volume	% Change
1	CME Group	3,442,766,942	3,161,476,638	8.90%
2	Intercontinental Exchange	2,276,171,019	2,558,489,589	-11.00%
3	Eurex	2,097,974,756	2,190,727,275	-4.20%
4	National Stock Exchange of India	1,880,362,513	2,127,151,585	-11.60%
5	BM&FBovespa	1,417,925,815	1,603,706,918	-11.60%
6	Moscow Exchange	1,413,222,196	1,134,477,258	24.60%
7	CBOE Holdings	1,325,391,523	1,187,642,669	11.60%
8	Nasdaq OMX	1,127,130,071	1,142,955,206	-1.40%
9	Shanghai Futures Exchange	842,294,223	642,473,980	31.10%
10	Dalian Commodity Exchange	769,637,041	700,500,777	9.90%
11	BSE	725,841,680	254,845,929	184.80%
12	Korea Exchange	677,789,082	820,664,621	-17.40%
13	Zhengzhou Commodity Exchange	676,343,283	525,299,023	28.80%
14	Hong Kong Exchanges & Clearing	319,577,388	301,128,507	6.10%
15	Japan Exchange	309,732,384	366,234,062	-15.40%
16	JSE Securities Exchange	304,003,143	254,514,072	19.40%
17	ASX	244,070,858	261,790,908	-6.80%
18	China Financial Futures Exchange	217,581,145	193,549,311	12.40%
19	Taiwan Futures Exchange	202,227,653	153,225,238	32.00%
20	BATS Exchange	201,985,667	151,814,889	33.00%
21	TMX Group	168,474,076	155,753,473	8.20%
22	Euronext Derivatives Market 3	144,058,758	147,355,797	-2.20%
23	Miami International Securities Exchange	134,535,972	39,430,903	241.20%
24	Multi Commodity Exchange of India	133,751,848	264,627,693	-49.50%
25	Metropolitan Stock Exchange of India 4	124,245,938	529,373,957	-76.50%
26	Singapore Exchange	120,398,368	112,077,267	7.40%
27	Rosario Futures Exchange	65,187,932	51,176,700	27.40%
28	Tel-Aviv Stock Exchange	64,052,496	60,514,431	5.80%
29	Borsa Istanbul	58,703,603	53,172,365	10.40%
30	MEFF	56,304,885	54,694,502	2.90%
31	London Stock Exchange Group	50,492,691	50,384,211	0.20%
32	Tokyo Financial Exchange	40,900,423	65,527,790	-37.60%
33	Thailand Futures Exchange	36,021,150	16,164,126	122.80%
34	National Commodity & Derivatives Exchange	30,129,128	32,435,100	-7.10%
35	Mexican Derivatives Exchange	29,913,972	27,358,232	9.30%
36	United Stock Exchange of India	24,819,403	45,132,176	-45.00%
37	Tokyo Commodity Exchange 5	21,856,063	26,845,712	-18.60%
38	Oslo Stock Exchange	16,966,331	11,693,959	45.10%
39	Malaysia Derivatives Exchange	12,313,490	10,621,629	15.90%
40	Dubai Gold & Commodities Exchange	11,789,063	13,759,255	-14.30%

Table 1.5: *Continued*

Rank	Exchange	Jan-Dec 2014 Volume	Jan-Dec 2013 Volume	% Change
41	OneChicago	10,907,977	9,515,194	14.60%
42	Athens Derivatives Exchange	10,798,988	9,204,155	17.30%
43	Warsaw Stock Exchange	9,481,427	12,615,336	-24.80%
44	CEE Stock Exchange Group	7,631,540	8,106,798	-5.90%
45	Pakistan Mercantile Exchange	3,572,003	4,608,831	-22.50%
46	Minneapolis Grain Exchange	2,177,740	1,483,657	46.80%
47	Dubai Mercantile Exchange	2,119,936	1,600,918	32.40%
48	New Zealand Futures Exchange	1,138,576	1,140,966	-0.20%
49	Bolsa de Valores de Colombia	941,620	685,133	37.40%
50	Indonesia Commodity & Derivatives Exchange	691,238	934,685	-26.00%
51	Eris Exchange	489,305	304,080	60.90%
52	Osaka Dojima Commodity Exchange	309,874	261,445	18.50%
53	Mercado a Termino de Buenos Aires	234,351	255,537	-8.30%

Note: Volume refers to the number of contracts traded and/or cleared during the year.
Source: Futures Industry Association

Currently, BD offers three categories of derivatives namely; commodity derivatives, equity derivatives and financial derivatives. Commodities derivatives include; gold and crude palm oil futures, among others. Equities derivatives include index futures, index options and single stock futures (SSFs), while interest rates derivatives include 3-month KLIBOR futures and 3-year MGS and 5-year MGS futures (refer Table 1.6 below). The derivatives are available for trade from 8.45 a.m. to 12:45 p.m. and 2:30 p.m. to 5:15 p.m., Monday to Friday.

Table 1.6: Products available at Bursa Derivatives

Type	Code
<u>Commodity derivatives</u>	
Gold futures	FGDL
Crude palm oil futures	FCPO
USD RBD Palm Olein Futures	FPOL
USD Crude Palm Oil Futures	FUPO
Crude Palm Kernel Oil Futures	FPKO
Options on Crude Palm Oil Futures	OCPO
<u>Equity derivatives</u>	
FTSE Bursa Malaysia KLCI Futures	FBM-FKLI
FTSE Bursa Malaysia KLCI Options	FBM-OKLI
Single Stock Futures	SSFs
<u>Financial derivatives</u>	
3 Month Kuala Lumpur Interbank Offered Rate Futures	FKB3
3-Year Malaysian Government Securities Futures	FMG3
5-Year Malaysian Government Securities Futures	FMG5

Note: All BMD products are traded on CME Globex trading platform beginning 20 September 2010.
Source: World Federation of Exchanges

The FBM-FKLI index futures were introduced on the 15 December 1995. Its value is derived from FBM-KLCI stock index which tracks the performance of the 30 constituent stocks with the largest market capitalisation. Over the years, the contract continues to experience steady growth in terms of volume and open interest owing to its importance as a price discovery and risk-management tool. Thus, it is important to gauge how these two important functions of the index futures are likely to be affected by the tick size reduction in the underlying market. It is worth noting that the index futures continue to trade in its original tick size of RM25 as shown in the contract specification below.

Table 1.7: Contract specification for the index futures contract

Contract Code	FKLI
Underlying Instrument	FTSE Bursa Malaysia Kuala Lumpur Composite Index (FBM KLCI)
Contract Size	FBM KLCI multiplied by RM50
Minimum Price Fluctuation	0.5 index point valued at RM25
Daily Price Limits	20% per trading session for the respective contract months except the spot month contract. There shall be no price limits for the spot month contract. There will be no price limit for the second month contract for the final five Business Days before expiration.
Contract Months	Spot month, the next month and the next two calendar quarterly months. The calendar quarterly months are March, June, September and December.
Trading Hours	✓First trading session : Malaysian time 8:45 a.m. to 12:45 p.m.
	✓Second trading session : Malaysian time 2:30 p.m. to 5:15 p.m.
Final Trading Day	The last Business Day of the contract month.
Final Settlement	Cash Settlement based on the Final Settlement Value.
Final Settlement Value	The Final Settlement Value shall be the average value, rounded to the nearest 0.5 of an index point (values of 0.25 or 0.75 and above being rounded upwards), taken at every 15 seconds or at such intervals as may be determined by the Exchange from time to time from 3.45:30 p.m. to 4.45:15 p.m. plus one value after 5.00pm of the FBM KLCI on the Final Trading Day excepting the 3 highest and 3 lowest values.
Speculative Position Limit	✓Maximum number of net long or net short positions to be held: 10,000 contracts for all months combined.

Source: Bursa Malaysia Berhad

1.4. Summary of hypotheses and findings

As noted above, tick size plays an important role in the overall functioning of a market. Thus, exchanges would be interested in finding answers to the following two research questions:

1. What is the impact of lowering the tick sizes on the spot index trading volume and in turn on the inter-market relationship between the spot and futures market?
2. What is the impact of the tick size reduction on the price discovery role and hedging effectiveness of the index futures?

We address the first question in Chapter 4. In general, the empirical evidence suggest that reducing the tick size leads to a decline in spreads, however the effect on depths is less certain and hence on trading volume.

In the context of Bursa Malaysia, however, it is expected that the lower tick size will lead to higher trading activity. First, Chung, Kim & Kitsabunnarat (2005) find that the tick sizes are not only a significant binding constraint on the spreads for large stocks but also for higher priced stocks given that the exchange uses tick that varies with prices. Therefore, the constituent stocks may experience greater reduction in spreads because these stocks are large and some are trading at higher prices (Hsieh et al. 2008). Consequently, the lower trading cost will induce traders to trade more often and attract new investors to start trading, leading to higher trading volume (Harris 1994). Second, Chung et al. (2005) also find that traders do not usually quote higher depth for stocks with larger tick, which implies that the impact of the lower tick sizes on market depth is minimal and hence on traders' ability to trade. As expected, we find evidence to suggest that spot index volume is significantly higher post-tick period. In the same line of arguments, we expect that the unexpected component of spot index volume represents trade that serves to strengthen the inter-market relationship between spot and futures indices. First, traders will be able to incorporate stock specific information more efficiently due to lower trading costs after the tick reduction. In other words, the ability to trade the underlying reduces the basis (Alexander 2008b, p.67). Secondly, it can be implied that the impact of the lower tick on arbitrageurs' ability and willingness to execute their trades is minimal, given that traders in Bursa Malaysia do not normally quote higher depth for higher tick stocks (Chung et al. 2005). Our results suggest that the unexpected trading volume after the tick reduction represents trades that serves to narrow the mispricing, an indication that traders are able to incorporate information effectively and respond to mispricing more quickly. Alternatively, it could be inferred that the lower tick does not causes speculators' trades to exceed those of arbitrageurs' in the composition of the unexpected trading volume (Cummings & Frino 2011).

Thus, the lower tick size leads to higher trading activity in the underlying market, which in turn reduces inter-market price discrepancies between the spot and futures indices. The second research question is addressed in Chapters 5 and 6.

In Chapter 5, we examine the price discovery role of the index futures, the ability of the market to incorporate information ahead of the underlying. Specifically, we measure the speed at which both markets revert to the equilibrium level. We find that the futures continue to incorporate information ahead of its underlying, while the spot reverts towards equilibrium at a greater speed after the tick reduction, confirming better incorporation of stock specific information in the underlying market. Clearly, these suggest that the lower tick improves the reliability of the index futures as a price discovery tool. Finally, in Chapter 6, we assess the hedging effectiveness of the index futures pre-and-post tick reduction. The hedge ratios are significantly higher after the tick reduction indicating stronger relationship between the spot and futures indices. Likewise, when we compare the hedging effectiveness using risk minimisation and utility maximisation criterions, we find evidence to suggest that traders are able to hedge price risk more effectively after the tick reduction.

In conclusion then, the lowering of tick size in emerging Malaysian market seems to improve spot index liquidity and in turn strengthens the inter-market relationship between the spot and futures indices. Consequently, we find improvement in the reliability and effectiveness of the index futures as a source of price discovery and price-setting mechanisms.

1.5. Structure of the thesis

The thesis is structured as follows. The following chapter comprehensively discusses the theoretical and empirical literatures on how likely would reduction in tick sizes affects the spot index liquidity and in turn on the inter-market relationship between the spot and futures indices. In addition, literatures concerning the price discovery role and hedging effectiveness of the index futures are also reviewed given that these two main functions of index futures are critically dependent on the strength of the inter-market relationship. The chapter also develops the hypotheses tested in our empirical studies. Chapter three discusses the data and methodology used in this study. Chapter four, five and six present the empirical findings. Chapter seven concludes the study, highlighting the limitations and suggestions for further research.

CHAPTER 2

Theoretical and empirical literature

From the discussion in the previous chapter, it is evident that tick size plays an important role in the overall functioning of the capital markets as it directly affects market liquidity. The interesting question to be asked is whether lowering the tick size improves spot index liquidity and in turn strengthens the relationship between spot index and index futures markets. If so, does the tick reduction favourably affect the price discovery role and hedging effectiveness of the index futures?

We begin this section by first discussing the reasons on why exchanges impose tick rules and how would stock market liquidity be affected if it is reduced. Next, we review the theoretical relationship between spot and futures and why would this relationship may not hold in practice. We focus our attention on trading cost differential between these two markets because it is directly related to the size of the tick. Then, we discuss the reasons on why increment in liquidity caused by the lower tick may not necessarily improve the pricing efficiency of the index futures. Finally, we review the literature on the price discovery role and hedging effectiveness of the index futures, which critically depend on whether the index futures are efficiently priced. Our hypotheses are discussed at the end of this chapter.

2.1. Tick size and stock market liquidity

In this section, we discuss the theory on why exchanges impose tick rules, the benefits and costs associated with it and the importance of setting an optimal tick size. Next, we discuss the argument for and against the move of lowering the tick and the possible effects on stock market liquidity if the tick is reduced. The justification for using the underlying trading volume as the proxy for liquidity is also presented.

2.1.1. The benefits & costs of tick size

Contrary to popular beliefs the optimal level of tick size is not zero. The extant literature highlights several reasons as to why exchanges impose tick rules. These are discussed below.

2.1.1.1. Reduced time in negotiation

First, tick size limits the number of prices available for traders to use. This reduces the time spent in negotiations (Harris 1991). For example, suppose a buyer place a limit order to buy at £15.09 and a seller place a limit order to sell at £15.11, assuming that the tick size is £0.01, then it is likely that no trade would take place. However, if the tick is £0.05, trade would most likely to take place if both traders are willing to round their orders to the nearest price point i.e. £15.10. Thus, tick size serves as a way to deter excessive negotiation amongst traders (Brown et al. 1991; Pavabutr & Prangwattananon 2009).

2.1.1.2. Simplified trading environment and reduce errors

Second, a wider tick size decreases the amount of information that need to be tracked by traders (Angel 1997). For example, assuming that the tick is £0.05, it is easier for traders to track the 20 prices points available between £10 and £11 in comparison to if the tick is £0.01. In other words, tick size serves as a tool to reduce costly human mistakes, such as key-in errors, while trading (Angel 2012).

2.1.1.3. Provides a floor on the bid-ask spread

Third, tick size provides a floor on the bid-ask spread, which determines traders' profitability. For liquidity demanders, the spread represents the round-trip transactions cost (excluding commissions) for buying and selling shares. For liquidity supplier, however, the bid-ask spread is an important part of revenue. Thus, a lower tick size may benefits liquidity demanders, however, it may discourage liquidity suppliers from posting liquidity in the market due to increased cost of supplying liquidity.

2.1.1.4. Protection for limit orders limit order traders

Finally, the tick serves as a protection for liquidity suppliers who have displayed their orders in the limit order book[11] by making other liquidity suppliers pay an economically significant amount more, which is determined by the tick size, to trade ahead of them. For example, suppose that an investor places a limit order to purchase a stock at £10.00 and the order is displayed in the limit order book. If another investor arrives who also wants to buy at £10.00, then the new investor's order would have a lower priority. When a market sell order comes in, the first investor's order at that price gets filled first.

However, if the second investor is allowed to bid at £10.01, assuming that the tick is £0.01, then the higher price would put that second investor at the front of the queue, even though there is a little difference in price. If this is the case, investors may switch from limit order to market order strategy due to higher risk of front-running. As a consequence, traders may incur higher trading cost and lower depths, which ultimately may lead to deterioration in market transparency (Harris 1999).[12]

2.1.2. The optimal tick size

The optimal tick size thus represents a tradeoff. A wider tick can improve liquidity as it gives more incentives for investors to supply liquidity and reduces the negotiation time of traders. Conversely, a wider tick can reduce liquidity simply by making it too expensive for investors to trade.

A narrower tick size, on the other hand, can improve liquidity by attracting more investors. However, a narrower tick may reduce liquidity as it can increase the cost of supplying liquidity and the risk of risk of front-running. Thus, in setting the optimal tick size, exchange must balance the benefits and costs of tick size so as to ensure a level playing field for all market participants.

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[11] A limit order is an order to trade that specifies a specific price. For example, an investor may place an order to purchase 1,000 shares of BP at £5.00. This means that the investor is not willing to pay more than £5.00 and the order cannot be executed at a higher price, but it can be executed at a lower price.

[12] Public orders in limit order books allow investors to trade fast in quantity they require at reasonable prices. This reduces investors trading costs and makes market less volatile. Thus, it is important to protect liquidity suppliers in the limit order books.

2.1.3. The case for and against lowering the tick size

As noted in the previous chapter, there has been a trend for exchanges around the world to reduce the tick size. The objective is to find the optimal tick size that will improve liquidity and enable price discovery.

Proponents of lower tick size argue that a lower tick could lower the bid-ask spread (Harris 1994), as competition amongst liquidity supplier increases (Ahn et al. 2007), especially so if the tick size represent a significant binding constraint on the stock price i.e. for one-tick spread stocks.[13] Consequently, trading volume may increase given the lower transaction costs.

Opponents on the other hand, argue that a lower tick size may cause the order priority rules less meaningful and thus increases the risk of front-running (Harris 1997). Consequently, liquidity suppliers are likely to reduce market depth (Zhao & Chung 2006), adversely affecting traders who trade in sizes far larger than what available at the inside spread[14] (Jones & Lipson 2001). Further, they argue that lower tick may increase negotiation cost (Hameed & Terry 1998), and thus trading volume may not increase as anticipated.

Therefore, although a lower tick may help cut transaction costs, due to possible decline in profitability coupled with higher risk of front-running, there are possibilities that trading volume may not improve (Pavabutr & Prangwattananon 2009).

2.1.3.1. Empirical evidence

There is quite an extensive academic literature that has examined the effect of reducing the tick size on stock market liquidity. However, the findings are inconclusive. In general, these studies find that when the ticks are reduced, bid-ask spreads fell. However, the impact on depth is less certain, and hence on trading volume. In other words, the impact of tick size reduction on the trading volume is not straightforward as

[13] That is, the tick size binds the bid-ask spread by not allowing the spread to decline to competitive levels (Kurov & Zabotina 2005). The literature suggest that low-priced and large stocks are more likely to be binded by a given tick size (Porter & Weaver 1997; Chung & Chuwonganant 2002) and therefore are most likely to experience greater reduction in spread due to reduction in tick size (Hsieh et al. 2008).
[14] The space between the current best bid and offer.

it depends on how the demand and supply of liquidity are affected by lower trading costs because of smaller tick sizes.

The AMEX has been lowering its tick size since 1992. The tick was reduced from $\$1/8$ to $\$1/16$ (teenies) for all stocks traded below \$5 on 3 September 1992. Ahn, Cao, & Choe (1996) find the spreads decline substantially following the reduction. However, they find no significant impact of the tick reduction on market depth and trading volume. When the tick was reduced to teenies for all stocks above \$1, Ronen & Weaver (2001) also find spreads decline, however depths do not. In fact, they do find trading volume is significantly higher post-tick reduction period.

The NYSE move to teenies on 24 June 1997, Goldstein & Kavajecz (2000) find lower spreads and depths after the tick reduction. Further, they find that liquidity demanders trading small orders benefit from the tick size reduction. However, liquidity demander trading large orders did not benefit, especially if those stocks are inactively traded.[15] They conclude that the optimal tick should be lower (higher) for actively (inactively) traded stocks. In support of Goldstein & Kavajecz's findings, Jones & Lipson (2001) find that trading costs increases, even though spreads decline, for traders submitting large orders due to reduction in depth after the change to teenies. Similarly, Wu, Krehbiel & Brorsen (2011) show that a reduction in tick size can indeed increase transaction costs especially for high-price and low-volume stocks, due reduction in market depth.

Similarly, Van Ness, Van Ness & Pruitt (2000) examine the impact of the move from eigths to sixteenths on market liquidity. They find spread decline significantly, depth increases in Nasdaq but declines on the NYSE and AMEX. Further, trading volume remain unchanged for AMEX and Nasdaq but increases on the NYSE.

On 15 April 1996, Toronto Stock Exchange reduced the tick size from (Canadian Dollars) $C\$1/8$ to (Canadian Dollars) $C\$0.05$ for stocks trading above (Canadian Dollars) C\$5. Bacidore (1997) finds both spreads and depths decline. Porter & Weaver

[15] This is consistent with Werner's et al.(2015) prediction.

(1997) suggest that reduction in spreads is greater for low-priced and high-volume stocks. However, Bacidore (1997) find that trading volume remain unchanged.

Aitken & Comerton-Forde (2005) investigate the impact of a lower tick in the Australian Stock Exchange (ASX). The new tick structures was implemented on 4 December 1995, for stocks priced below (Australian Dollars) $A0.50 and above (Australian Dollars) $A10. They find lower spreads and depth for the stocks priced below (Australian Dollars) $A0.50. Using depth to number of shares outstanding ratio, they observe that liquidity is higher especially for high volume stocks. For the high-priced stocks, however, they find that spread increases by 30% for the inactively traded stocks. They reason that the tick was too narrow for these stocks. Thus, they conclude that ASX may consider to incorporate the level of trading activity, in addition to the price level, in setting their optimal tick size. In other words, the optimal tick size for a stock should be related to its liquidity and price (Buti et al. 2013).

The Tokyo Stock Exchange, on April 13 1998, reduce the size of their tick. Ahn, Cai, Chan & Hamao (2007) find spread declines by 20% to 50%. However, they do not find any significant evidence to suggest an increment in trading volume.

Stock Exchange of Singapore (SES), on 18 July 1994, reduced the minimum price increments from (Singapore Dollars) $0.50 to (Singapore Dollars) $0.10 for stocks trading above $25. Lau & Mcinish (1995) find that the reduction causes both the spreads and depths to significantly decline but not on trading volume. In contrast, Hameed & Terry (1998) find higher trading volume for the actively traded but not for the inactively traded stocks, which they attributed to higher negotiation cost caused by the lower tick size.

In Jakarta Stock Exchange (JSX), the tick size was (Rupiah) Rp25 regardless of stock prices. On 3 July 2000, it was reduced to (Rupiah) Rp5. Purwoto & Tandelilin (2004) find that both spread and depth declined significantly. Further, they find trading volume increases for low-priced stocks. For high-priced stocks, however, they suggest that the absolute tick size of (Rupiah) Rp5 is too low which decrease the investors' willingness to trade. They conclude their study by recommending that the JSX moves from using a single absolute tick size to using a tick size that is a step function of the stock price.

On 3 January 2005, the JSX introduced a new tick size structure of (Rupiah) Rp10 affecting stock prices in the range of (Rupiah) Rp500 to (Rupiah) Rp2000. Ekaputra & Ahmad (2007) find that the spreads and depth of the affected stocks decline significantly. Using depth to spread ratio as a proxy for liquidity, they conclude that the introduction of the new tick improves liquidity for the affected stocks.

For the Stock Exchange of Thailand (SET), Pavabutr and Prangwattananon (2009) report a fall in bid-ask spreads and depth for the stocks priced below (Thai Baht) THB25 affected by the tick reduction on the 5 Nov 2001. However, they do not find significant change in trading volume for the period, from 5 Oct 2001 to 30 Nov 2001, considered in their study.

Hsieh, Chuang, & Lin (2008) investigate the impact of the tick size reduction implemented on March 1, 2005, in Taiwan Stock Exchange. They find both spread and depth decline, and that trading volume is lower especially for low-priced and inactively traded stocks. Kuo, Huang & Chen (2010) suggest that traders employ smaller trade size following the reduction to hide private information, which leads overall decline in liquidity.

In Hong Kong Exchanges (HKEx), Pan, Song & Tao (2012) find that both spread and depth decline for stocks trading in the range of (Hong Kong Dollar) HK$2 to (Hong Kong Dollar) HK$20 after the tick reduction on the 24 July 2006. Further, they find that depth decreases significantly for the actively traded stocks, while there is no significance change for the low volume stocks. They suggest that large traders are negatively affected by the tick size reduction. They did not however examine the impact on trading volume.

2.1.3.2. Proxy for market liquidity

Liquidity is proxied by many variables such as trading volume, bid-ask spread and market depth. In this study, the focus is on the spot index trading volume. There are several reasons as to why we choose trading volume. First, trading volume captures the net impact of tick size on the spreads and depth. In other words, trading volume is an important factor in explaining spread and depth (Hsieh et al. 2008). Further, trading volume is one of the most important measures of market quality (Angel 2012). Second, trading volume could also proxy for information arrival in the market. This is particularly important for us in addressing the first research question concerning the impact of the tick size reduction on the inter-market relationship between the spot and futures market. For this purpose, we decompose the raw trading volume into its expected and unexpected components, whereby the unexpected components represents trades that may weakens or strengthens the spot and futures relationship (Cummings & Frino 2011).

Let us now review the theoretical relationship between futures and spot prices.

2.2. The pricing efficiency of index futures

The cost-of-carry model gives the theoretical relationship between the price of an index futures and its underlying spot index as follows:

$$F_t^* = S_t e^{(r-d)(T-t)} \tag{II.1.1}$$

where F_t and S_t are the prices of index futures and spot index observed at time t, respectively. $(r-d)$ is the net cost of holding the underlying stocks in the spot index, where r and d, respectively, are the risk-less interest rate (the opportunity cost of holding shares) and dividend yield (benefits accrued from holding a stock index portfolio) on the underlying index. T is the expiration date, so $(T-t)$ is the time to maturity of the futures contract. The futures price converges to the price of the spot index as the futures contract approaches maturity because the basis i.e. the difference between the futures and spot prices, converges to zero at expiration. In this particular model, it is assumed that the risk-less interest rate and dividend yield are known, constant and compounded continuously through time.

In a perfectly efficient market and in the absence of market frictions or impediments, in particular, no transaction costs, no margin requirements, no taxes, unlimited short selling, etc, the cost-of-carry relationship should hold at every instant t throughout the futures contract life because prices are assumed to adjust fully and instantaneously to incoming information. If so, the rate of price appreciation in the index futures, f_t is equal to the relative price change of the stock index, s_t minus the net cost of carry, $(r-d)$ as follows:

$$f_t = s_t - (r-d) \tag{II.1.2}$$

where $f_t = \ln(F_t/F_{t-1})$ and $s_t = \ln\left(S_t/S_{t-1}\right)$.

Stoll & Whaley (1990) discuss five important implications of Eq. (II.1.2) based on the assumption that the cost-of-carry relation in Eq. (II.1.1) holds at all points in time. First, the expected index futures return, $E(f_t)$ equals the expected spot index returns, $E(s_t)$ minus the net cost of carry, $(r-d)$. Second, the standard deviation of index futures return equals the standard deviation of spot index return. Third, the contemporaneous returns of both index futures and spot index are perfectly positively correlated. Fourth, the non-contemporaneous returns of both index futures and spot index are uncorrelated, and finally, the returns on both index futures and spot index are serially uncorrelated. The above implications imply that one market should not lead the other or one market should not help to predict returns in the other. That is, the prices of the index futures and spot index should simultaneously reflect the new information as the information reaches the markets. In other words, there should be no price discrepancies between index futures and its underlying index.

In practice, however, Eq. (II.1.1) does not exactly hold. Instead of observing F_t^*, we observe F_t as follows:

$$F_t = F_t^* + \frac{F_t - F_t^*}{S_t} S_t \qquad \text{(II.1.3)}$$

where the second component on the right hand side of Eq. (II.1.3) is the mispricing, defined as the difference between the observed futures price, F_t and its intrinsic price, F_t^* deflated by the observed spot price[16] at time t. There are several factors that may cause this mispricing as we shall discuss next.

2.2.1. Reasons for mispricing

Mispricing or deviations from the cost-of-carry relation may occur due to four main reasons as outlined by Stoll & Whaley (1990).

First, some of the constituent stocks may not trade in every interval when the stock index is recalculated. A component stock that is not traded at the time the index is updated will be captured in the index by its last recorded transaction price. This causes some delay in responding to market-wide information. The futures price, on the other hand, adjusts instantaneously to new information because of its tradability.

Second, bid-ask bounce effect may cause negative serial correlation in both spot and futures returns series even though the true returns are serially independent. Bid-ask bounce effect exist because, in the absence of new information, the transaction prices used in computing the returns series tend to fluctuate randomly between bid and ask levels. However, it is more prevalent in futures as it is a tradable instrument (Stoll & Whaley 1990).

Third, time delays in the calculation and reporting of the stock index value would also tend to show futures market returns to lead stock index returns. Stoll & Whaley (1990) identify three possible time delays that may cause this: delay in entering the stock transaction into the computer; delay in computing and transmitting the new index value and; delay in recording stock index value at the futures exchange. However, the effect of this is minimal as most exchanges around the world are now able to recalculate and

[16] It is also common to deflate the mispricing by the intrinsic futures price, F_t^* (Sutcliffe 2006, p.85)

disseminates the updated spot index in every fifteen seconds given the advent of new technology.

Finally, traders may prefer to exploit market wide information by trading the index futures rather than the constituent stocks because transaction costs are lower and higher degree of leverage attainable. In this case futures prices moves first and then the stocks prices will adjust accordingly when arbitrageurs respond to the mispricing. When the mispricing is positive, arbitrageurs sell futures and buy index portfolio and if the mispricing is negative, arbitrageurs' can earn risk-less profit by buying the futures and selling the portfolio of stocks, and in doing so minimises the mispricing. Thus, it is widely accepted that the cost-of-carry relationship is maintained by arbitrageurs (see for example, MacKinlay & Ramaswamy 1988).

It is also worth noting that, the difference between the observed futures and observed spot prices (i.e the basis, B_t) is given by the following:

$$B_t = S_t - S_t e^{(r-d)(T-t)} + \frac{F_t - F_t^*}{S_t} S_t \tag{II.1.4}$$

There are two components in the basis, the fair basis and the mispricing. It is the mispricing that is of concern to traders because there is less uncertainty with regard to the fair basis. The reason is that; discount rates, dividend yields and time are the only factors affecting the fair basis (Alexander & Barbosa 2008). Whereas, it is more challenging to predict the mispricing. Therefore, in this study the term basis, mispricing or rather the pricing efficiency of index futures are used interchangably.

2.2.2. Empirical evidence

Numerous previous studies find evidence of deviation from the no-arbitrage relationship. In the US, Neal (1996) analyses the pricing efficiency S&P500 index futures. He finds that the contract is overpriced roughly 67% of the time, for the period from January to March 1989. For the MMI[17] index futures, Finnerty & Park (1988) find that the mispricing is large enough to cover for transaction costs.

In Canada, Park & Switzer (1995) find that the futures are on average underpriced throughout the sample period from 1988 to 1992. Further, they find that the magnitude of mispricing gets very small especially after the introduction of the TIPs (ETFs) on 9 March 1990. In Korea, Gay & Jung (1999) find evidence of underpricing which they attribute to difficulty of short-selling the constituent of the KOSPI index. In Germany, Bühler & Kempf (1995) find that underpricing accounts for 79% of the mispricings for the DAX futures during the period from 1990 to 1992 even after allowing for transaction costs.

Puttonen & Martikainen (1991) find that the Finnish FOX index futures are underpriced (allowing for transaction costs) during the period from 1988 to 1990, which Puttonen (1993) reasons due to the absence of short selling in the underlying market. Similarly, in Netherland, Berglund & Kabir (1995) find evidence of underpricing for the EOE index futures throughout the period from 1991 to 1993. In Greece, Fassas (2010) find that the FTSE/ATHEX-20 index futures contract to be fairly priced, the deviations from the cost-of-carry model ranging between 0.4% and -1%. They suggest that difficulty in shorting the underlying stocks explain why underpricing accounts for 83% of the mispricing observed in their study.

Using daily data for the FTSE100 for 1984-1988, Yadav & Pope (1990) find that the average mispricing decline from 0.5% to 0.2% due to the Big Bang.[18] In their subsequent studies, using hourly data for 1986 to 1990, Yadav & Pope (1994) find frequent mispricing in excess of transaction costs and that there is no clear pattern of over or underpricing.

Butterworth & Holmes (2000) investigate the pricing efficiency of the FTSE 100 and the FTSE mid-250 index futures contracts relatives to their underlyings. Their results

[17] AMEX Major Market Index (MMI) is a price-weighted stock market index made up of 20 Blue Chips industrial stocks of major U.S. corporations.

[18] Big Bang refers to the day i.e. 27 October 1986 when the London Stock Exchange was substantially deregulated which led to lower trading costs.

show that these contracts tend to be efficiently priced. That is, mispricing tends to be smaller in magnitude especially for the well-established FTSE 100 index futures. They suggest that the mispricing observed for the newly introduced FTSE mid-250 futures are due to relatively higher costs of trading the constituent stocks. This implies that a lower tick may improve liquidity and in turn minimises the mispricing (Kumar & Seppi 1994). The reason is that the ability to trade the underlying stocks facilitates incorporation of information (Alexander 2008b, p.67). Further, higher liquidity in the underlying market facilitates arbitrage trades (Roll et al. 2007).

2.2.2.1. Liqudity and the index futures' pricing efficiency

However, the positive effect of lower tick sizes on liquidity and subsequently on the pricing efficiency is conditional on whether the unexpected trading volume represents trades by arbitrageurs and how quickly the stock specific information is reflected in the stock prices. Henker & Martens (2005), provide evidence of lower inter market discrepancies between S&P 500 index futures and its underlying due to significant increase in number of arbitrage trades following the introduction of the lower tick size in the NYSE. Further, Roll, Schwartz & Subrahmanyam (2007) and Chordia, Roll, & Subrahmanyam (2008) show that the increased liquidity after the tick size reductions in the NYSE is due to quicker incorporation of firm specific information in the market. In NASDAQ market, Chung & Hrazdil (2010) find improvement in market efficiency and liquidity following tick size reduction (from the sixteenth to decimalisation).

In contrast, Chen, Chou, & Chung (2009) find that reduction in the tick size leads to a deterioration in the pricing efficiency between SPDRs & S&P500 e-mini futures and ETFs & NASDAQ100 e-mini futures. They show that even though the bid-ask spreads decrease, the market depth also declines thus increasing the cost of trading particularly for large traders. As a result, arbitrageurs' ability and willingness to initiate trade weakens, which subsequently leads to deterioration in the pricing efficiency of the e-mini futures indices. In other words, an increase in trading volume following the tick size reduction may not represent arbitrageurs' trades, which helps in reducing the inter-market pricing discrepancies.

Further, even if arbitrageurs are not adversely affected by the tick size reduction, there are two other possibilities why the inter-market discrepancies may increase. First, if index futures are mispriced relative to its underlying, there is a possibility that speculators may use this signal by trading in the constituents stocks due to lower bid-ask spreads instead of trading in the futures market. As a consequence, inter-market pricing discrepancies may widen if speculators' trades exceed those of arbitrageurs' trades. Second, the deviation from the no-arbitrage relationship may be further magnified by the possibility of speculators with stock specific information trading more often and thereby attracting new speculators, given the lower trading cost (see, Bollen & Whaley 1998). This is particularly so for stocks with higher market capitalisation where speculators are able to act on stock specific information (Sutcliffe 2006, p.162). Similarly, there are two components of unexpected spot trading volume. One represents those of arbitrageurs, which narrow down inter-market price discrepancies, and the other represents those of speculators which widen these price discrepancies.

While the impact of tick size reduction on pricing efficiency remains a point of academic debate, there is an agreement that market efficiency is improved with the introduction of exchange-traded funds (ETFs) as they contain attractive features for index arbitrage. Park & Switzer (1995) find that the Toronto 35 index futures price has conformed to the theoretical value of Toronto 35 index much better after the introduction of TIPs. Switzer, Varson & Zghidi (2000) and Chu & Hsieh (2002) investigate the impact of the introduction of SPDRs on market efficiency. Both conclude that the introduction of the SPDRs improve the S&P500 index futures' pricing efficiency. Their results provide support for the hypothesis that ETFs facilitate arbitrage by simplifying the process of shorting. Kurov & Lasser (2002) find there is an increase in the speed of the adjustment to deviation from equilibrium prices which they attribute to the ease of establishing a spot NASDAQ-100 index position after the introduction of the tracking stock. They conclude that the introduction NASDAQ-100 Index Tracking Stocks (QQQs) facilitate spot-futures arbitrage and in turn improve the pricing efficiency of the futures index.

Traders use index futures as a price discovery tool and hedging instrument. That is, traders rely on futures prices to predict the spot prices and to minimise the price risk in their spot position. The magnitude and stability of the mispricing is of concern to them. A large mispricing suggest that it is unlikely that traders would be able to predict the spot price accurately and manage price risk efficiently (Garbade & Silber 1983). In the following two sections we review the literatures on the price discovery role and hedging effectiveness of index futures.

2.3. The price discovery role of index futures

Price discovery is an essential function performed by futures markets. This is so given the inherent advantages of trading futures. As such information may be reflected in the futures market more quickly than the spot market and hence adjusts to equilibrium level ahead of the underlying. Consequently, traders may find futures markets more informative about the true value of the underlying asset. In the following section, we discuss why futures are expected to incorporate information ahead of the spot. Next, we consider the reliability of futures in predicting the expected spot price. Finally, we review the empirical evidence concerning the lead-lag relationship between these two markets taking into account the effect of a lower tick size.

2.3.1. Why index futures are expected to incorporate information ahead of its underlying

There are a number of reasons as outlined by Chu, Hsieh & Tse (1999) for expecting the index futures to be the dominant source of price discovery. These are briefly discussed below:

2.3.1.1. Leverage hypothesis

The leverage hypothesis predicts that high leverage instrument such as index futures provide the best price discovery. The reason is that high leverage instrument provides higher return on investment. Thus, informed traders prefer to trade futures instead of the constituent stocks because with the smallest initial outlay, the traders get the same exposure as in the stock market. Chu, Hsieh & Tse (1999) suggest that the leverage hypothesis explain the dominant role of S&P 500 index futures in price discovery.

2.3.1.2. Information hypothesis

The information hypothesis predicts that index futures serve a more significant price discovery function because traders prefer to exploit market-wide information by trading in the futures market (Fleming et al. 1996). On the other hand, traders prefer to exploit stock specific information in the underlying stocks because the movement in the futures price will be much smaller in comparison to the prices of the affected shares (Sutcliffe 2006, p.162). Hence, it is more likely for informed traders to trade the index futures. This causes index futures price movement to lead spot price movement, provided that information specific to a few companies does not have trivial impact on the spot index (Cummings & Frino 2011). Frino, Walter & West (2000) empirically shown that traders with stock-specific (market-wide) information prefer to trade the spot index (index futures) in support of the information hypothesis.

2.3.1.3. Up-tick rule hypothesis

Due to no short-sell restrictions, bearish information may be incorporated first in the futures market and only later in the stock market. For example, if there is a bad news concerning the market in general, traders could take a short position by selling index futures, thereby immediately incorporating the effect of the information. Further, selling shares short may not be easily implemented due to uptick rule. That is, short selling could only be implemented in a rising market or when the last recorded return is non-negative. Thus, the uptick rule hypothesis favours futures in the process of price discovery.

2.3.1.4. Transaction cost hypothesis

The transaction cost hypothesis predicts that price discovery occurs mainly in markets with the lowest transaction cost. For market wide-information, establishing a position that consist of all the constituent stocks is very expensive because each of the constituent stocks are subject to bid-ask spreads and broker’s commission, whereas index futures are quoted in narrower bid-ask spreads. Thus, informed traders prefer to exploit their information in the futures market due to lower trading cost. For example, Fleming, Ostdiek & Whaley (1996) find that the S&P500 futures lead both the S&P500

and S&P100 indices (purged of stale price effects) and the S&P500 options consistent with the transaction hypothesis.

However, there is one exception with regard to the conclusion concerning the transaction cost hypothesis above, Fleming et al. (1996) argue that the transaction cost to buy one particular stock is lower compared to buying the index futures. Hence, firm specific information would tend to be revealed first in the stock market. Thus, if information specific to a few influential companies in the index have a huge impact in the prices of a few companies, the spot index price may lead the index futures instead.[19]

2.3.1.5. Technical reasons

In addition to the above predictions, there are other technical reasons as noted earlier that may explain why index futures lead the spot index. These include thin trading effect, bid-ask bounce effect and time delays in reporting of the index value (please refer page 28).

Thin trading effect may induce positive autocorrelation in the spot return series. To account for this, Stoll & Whaley (1990) use ARMA model to purge thin trading effect. Alternatively, quote data may be used instead of transaction data. For example, Shyy, Vijayraghavan & Scott-Quinn (1996) find that the CAC 40 index futures lead the CAC 40 index, however, the feedback effect from spot to futures is much more stronger when quotes data are used. However, it is noted that in general futures' lead over spot is stronger even after thin trading effects have been taken into account. For example, Tse (1995) finds that the lead of Nikkei 225 futures does not disappear even after controlling for thin trading effects.

To recap, index futures market enjoys the advantages of high leverage, low trading costs and absence of uptick rule, which explains why futures market is expected to incorporate information ahead of its underlying. This implies that futures market could be used as an instrument to infer the expected price of the underlying asset and hence assist them in making sound financial decisions.

[19] This contradict the leverage hypothesis which suggests that index futures should lead the spot index due to small outlays required to transact in the index futures (Fleming et al. 1996).

We review the theoretical background on how do traders use futures price to infer the future spot price in the following section.

2.3.2. How well does the futures price forecast the expected spot price

There are four theories that explain how traders may use futures price to predict the expected spot price. These are the expectations hypothesis, normal backwardation, contango and the modern portfolio theory. We briefly explain each in the following section.[20]

The expectations hypothesis states that the current futures price, F_0 equals the expected price of future spot price, $E(P_t)$, i.e. $F_0 = E(P_T)$. It is assumes that traders are risk neutral and thus expect no profit in trading futures. This hypothesis, however, ignores the risk premiums in futures pricing especially when the expected spot prices are uncertain.

The backwardation theory suggests that, short hedgers must compensate speculators to take the opposite position. That is, speculators will only take the long position if the futures price is below the expected spot price i.e. $E(P_T) - F_0$. In this market, futures price is below the future spot price and converge at maturity. The opposite is for the contango, which suggest that long hedgers must provide provide profit for speculators to take the short position. Thus, the contango theory holds that current futures price, F_0 must exceed the expectation of spot price, $E\left(P_T\right)$.

The above three traditional hypotheses all suggest that speculators are willing to trade if they are sufficiently compensated for the risk they take. Figure 2.1 shows the expected path of futures under the three traditional hypotheses.

The modern portfolio theory refined these hypotheses, whereby the the existence of risk premium is considered. To illustrate, consider a stock paying no dividends. If S_T denotes the expected stock price at time T and k denotes the required rate of return on

[20] For detailed explanation, reader may refer to Bodie, Kane & Marcus (2009).

the stock, then today's stock price should equal the present value of its expected future payoff as follows:

$$S_t = \frac{S_T}{(1+k)^T} \tag{II.2.1}$$

Also, from the spot-futures parity relationship, today's stock price is:

$$S_t = \frac{F_t}{(1+r_f)^T} \tag{II.2.2}$$

It is obvious that Eqs. (II.2.1) and (II.2.2) must be equal. Equating these terms yield:

$$F_t = S_T \left(\frac{1+r_f}{1+k} \right)^T \tag{II.2.3}$$

If k is greater than r_f (positive systematic risk/beta), F_t will be less than the expectation of S_T. A long futures position will provide a profit of $S_T - F_t$. While short position profit is the negative of $S_T - F_t$ and will have negative systematic risk. We shall now review the empirical evidence concerning the price discovery of index futures and how it may be affected by a lower trading costs caused by the lowering of tick sizes in the underlying market.

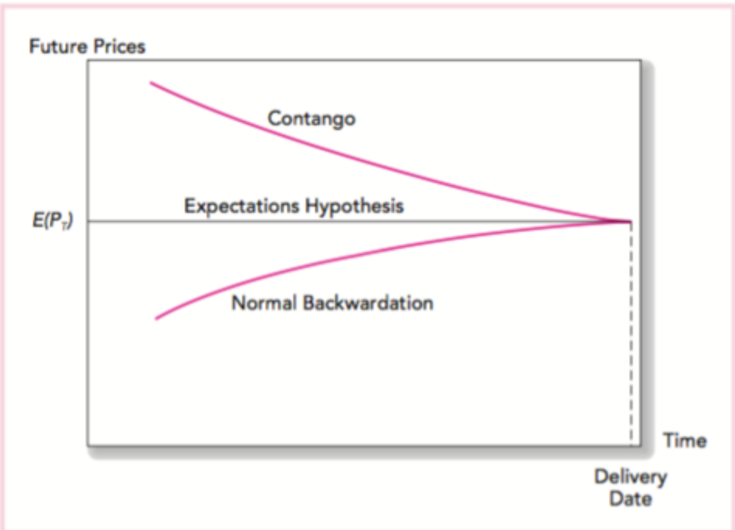

Fig. 2.1: Futures price over time, with the assumption that the expected spot price remains unchanged.
Source: Bodie, Kane and Marcus (2014)

2.3.3. Empirical evidence

The extant literature suggests that futures and spot returns are imperfectly, albeit strongly, contemporaneously correlated (see for example, Frino & West 1999; Zhong et al. 2004). That is, a lead-lag relationship exists between these two markets and hence one could be used to predict the other.

Generally, most of the empirical results show a bi-directional asymmetric lead-lag relationship, that is, a strong lead of the futures over the spot and a weak feedback effect of the spot lead over the futures. In other words, price discovery to some extent occurs in both markets, although futures' lead over spot is much stronger. Thus, in such cases, the futures market is said to contribute significantly to the discovery of the spot asset price. There are however evidence that suggest the lead of spot over futures is much stronger.

In Australia, Frino & West (1999) find the SPI futures lead the All Ordinary Index and that there is feedback effect from the the spot index to the index futures. In Germany, Grünbichler, Longstaff & Schwartz (1994) find the DAX futures leads spot by about 15-20 minutes and spot leads futures by 5 minutes. Similarly, in the United States, for the S&P500, stronger futures lead over spot is observed. For example, Kawaller, Koch & Koch (1987) find S&P500 futures prices lead spot prices by 20-45 minutes while the spot only affects futures prices less than 1 minute. Stoll & Whaley (1990) finds evidence that S&P500 and MMI futures leads the spot by about 5 minutes and at times as much as 10 minutes or more, and weak evidence of spot leads futures, a finding supported by Chan (1992). Further, Kutner & Sweeney (1991) examine the causal relationship between S&P 500 spot and futures using intraday data. Their results show that the futures lead the index (spot) by at least 20 minutes, where the index (spot) influences the futures for only 15 minutes. Ghosh (1993a) finds evidence of causality for the S&P500. De Jong & Nijman (1997) find the S&P500 spot leads the futures by 2 minutes, and the futures lead by 11 minutes. Pizzi, Economopoulos and O, Neill (1998) find S&P500 futures market leads the spot market by at least 20 minutes and spot lead futures by 3 to 4 minutes. These findings imply that the transmission of information from futures to spot is much stronger than from spot to futures.

In contrast however, Wahab & Lashgari (1993) find stronger evidence of spot lead the futures for S&P500 rather than from futures to spot of which they attribute to application of the cointegration analysis. Likewise, Chiang & Fong (2001) find that the Hang Seng Index (HSI) leads the futures and attribute this to the domination of HSI by a few major stocks, which have symmetric lead-lag relations with futures.

There is also evidence of uni-directional lead-lag relationship. For example, Shyy, Vijayraghavan & Scott-Quinn (1996) examine the issue of whether the lead-lag relationship would differ if bid-ask quotes midpoint data were used instead of transaction data. Using transaction prices data, they find futures lead spot. Using bid-ask prices, however, the lead relationship from futures to spot diminishes and feedback effect from spot to futures become significant. They argue that thin-trading and differences in trading mechanisms may explain why previous results show futures leading spot. Recent evidence by Judge & Reancharoen (2014) indicates that the SET50 index has a uni-directional lead over futures. They argue that the higher trading volume in the stock market in comparison to futures market[21] may explain the spot's lead over futures.

However, in Taiwan, Lee, Wu & Yang (2013) find that futures significantly lead spot returns and that foreign institutional trades represent the major source of information. The above findings imply that whenever new information arrives, traders may exploit the information in either futures or spot markets, thus price discovery occurs mainly in market in which traders choose to trade.

In the context of Malaysian market, Pok & Poshakwale (2004) find that the introduction of the index futures contracts improved information flows to the underlying stocks. This implies that the index futures in the emerging Malaysia market do play its price discovery role. Tan (2002) and Pok (2007) investigate the temporal relationship between futures and spot returns. The focus of their studies is on the impact of the imposition of selective capital controls.

[21] The trading volume in the spot markets ranges from 1 billion and 6 billion shares, while the number of futures contracts peaks at 45,000. Judge et. al. (2014) attribute this to the on going financial liberalisation in the Thailand capital market.

Tan (2002) finds futures lead the spot in the long run and a bi-directional short-run causality and that the capital control has significant impact on the futures market but not on the spot market. Pok (2007) finds that the withdrawal of foreign institutional investors significantly affect the lead-lag relationship between index futures and spot. Specifically, she finds that futures' lead are longer after the imposition of capital control and argues that it is due to the absence of foreign institutional investors.

It is believed that the relationship between stock index and index futures in emerging Malaysian market has changed due to the lowering tick sizes because traders may find it less costly for them to exploit information in the underlying market (Chan 1992). Further, due to maturation effect, both market may have become more integrated i.e. closely linked over time (Stoll & Whaley 1990).

Existing empirical evidence suggests that reduction of tick size improves the reliability of index futures as the bellwether instrument as it allows for better incorporation of stock specific information. For example, in Toronto Stock Exchange, Beaulieu, Ebrahmim & Morgan (2003) suggest that tick size reduction improves the price discovery role of TSE 35 index futures. Similarly, Chou & Chung (2006) find that the lower tick size on the ETFs (S&P500 ETFs; Nasdaq-100 ETFs; and DJIA) facilitates incorporation of information and that the index futures still the main source of price discovery. Chen & Gau (2009) find that the contribution of the index market to price discovery increases after the reduction in the minimum tick size, which they attribute to the transaction hypothesis.

On one hand, the move to lower the tick may facilitate the incorporation of stock specific information. If this is the case, the index futures ability to find the equilibrium price should improve. On the other hand, however, the lower tick size may cause index futures to delay in responding to both stock specific and market-wide information. First, if index futures are highly mispriced relative to its underlying, there is a possibility that speculators may use this signal by trading in the constituents stocks due to lower bid-ask spreads instead of trading in the futures market. As a consequence, mispricing may widen if speculators' trades exceed those of arbitrageurs' trades. Second, the mispricing may be further magnified by the possibility of speculators with stock specific information trading more often and thereby attracting new speculators, given the lower trading cost (Bollen & Whaley 1998). This is particularly so for stocks with higher market capitalisation where speculators are able to act on stock specific information (Sutcliffe 2006). In short, there are possibilities that the lowering of tick size may adversely affect the price discovery of index futures, it it causes futures to delay in responding to both market-wide and stock specific information. Therefore, it is important for us to assess the speed at which both spot and futures returns adjust to equilibrium level.

It is noted that the widely used lead-lag based regression models in investigating the lead-lag relationship between spot and futures do not provide an estimate that measures the extent of differential price movement. In other words, it only addresses the question of how far futures are leading or lagging the spot, but it does not tell us anything about the speed at which the futures and spot revert to equilibrium level. The speed of adjustment estimators used in Theobald & Yallup (1998) and Poshakwale & Theobald (2004) will enable the examination of differential speeds of adjustment when assessing the futures and spot lead-lag relationships. Consequently, we will be able to explain and justify the impact of the tick size reduction on the price discovery role of index futures. That is, by assessing the speed at which both prices adjust to equilibrium level, before and after the introduction of lower tick, we provide new evidence on the temporal relationship between futures and spot markets in the emerging Malaysian market. The speed of adjustment estimator(s) which is based on the partial adjustment model (Amihud & Mendelson 1987) is discussed in the methodology section. In addition, the Vector Error Correction Model (VECM) is also estimated for robustness.

2.4. Hedging effectiveness of the index futures

One important function of futures contract is to enable effective hedging. With futures contract traders are able to hedge price risk without the need to readjust their portfolio composition. Further, futures allow traders to hedge their positions either in a bullish or a bearish market. For example, a portfolio holder who expects to receive funds in four months' time, to buy additional stocks, and in the opinion that stocks are cheaper now compared to four months later, could hedge the risk of having to pay more four months later, by buying current index futures. In the event that the portfolio holder's opinion is correct, losses in having to acquire the stocks at a higher price will be offset or minimise by closing his index futures position at a higher price. Similarly, if the investor expects the market to move downward, the trader could execute short hedge strategy to protect his/her current positions.

2.4.1. How hedging transforms price risk to basis risk

Although hedging with futures eliminates price risk in the underlying spot, the hedger is exposed to basis risk, i.e., the risk that futures returns over time does not track exactly the spot returns. That is, hedging transforms price risk to basis risk[22] (Jorion 2007). Suppose, the pay-off of an unhedged spot position (π_u) is given by the difference between today's and yesterday's prices i.e. $\pi_u = S_t - S_{t-1}$. This pay-off is very much uncertain due to price risk. Whereas, the pay-off a hedged position (π_h) is;

$$\begin{aligned}\pi_h &= \left[(S_t - S_{t-1}) + (F_t - F_{t-1})\right] \\ &= \left[(S_t - F_t)\right] - \left[(S_{t-1} - F_{t-1})\right] \\ &= B_t - B_{t-1}\end{aligned} \tag{II.3.1}$$

Where $B = S - F$ is the basis, the difference in prices between spot and futures. Thus, the profit of a hedge strategy depends only on the movement in the basis. Similarly, a large basis or rather the mispricing (because of its dominant in the component of the basis, refer page 29) may affect hedgers' profitability and therefore on the effectiveness of a hedge strategy. In other words, the magnitude and stability of the mispricing is crucial for a successful hedging (Figlewski 1984). It is important for us to assess the hedging effectiveness of the FBM-FKLI stock index because the mispricing may widen following the introduction of the lower tick sizes given its inconclusive impact on the FBM-KLCI spot index liquidity (see for example, Ahn et al. 1996; Goldstein & Kavajecz 2000; Ronen & Weaver 2001; Jones & Lipson 2001). By doing so, we contribute to the literature and extend Pok, Poshakwale & Ford (2009) studies.

[22] Price risk refers to the risk of a decline in the value of a security of a portfolio.

In the next section, we discuss the theoretical perspective on why the need to hedge, following which we discuss the two main issues in futures hedging, namely; the determination of hedge ratio and the evaluation of hedging effectiveness. Finally, we review the existing empirical evidence.

2.4.2. The motives for hedging

According to Sutcliffe (2006) there are three main motives for hedging: (1) risk minimisation, (2) profit maximisation and (3) portfolio optimisation. We shall now briefly discuss each one of these motives.

2.4.2.1. Risk minimisation

A trader who views hedging as a risk minimisation strategy undertakes opposite but equal in magnitude a position in futures so as to immunise his/her standing against market uncertainties, rather than just liquidating the initial position in a risky asset. In this theory, investors are assumed to be extremely risk averse and endeavour to off-set or eliminate all possible losses in the underlying market by trading futures.

The hedge ratio is thus:

$$b = -(X_f / X_s) \tag{II.3.2}$$

where X_f and X_s are the value of the futures contracts and the spot assets held by the investor, respectively. This naïve or perfect hedge eliminates all the price risk provided there is no basis risk. As we discussed earlier, mispricing which is the dominant component of the basis risk may never be zero due to the dynamic relationship between index futures and spot index.

Thus, given the lack of perfect correlation between spot and futures prices, the optimum hedge ratio can never be one, even when the spot portfolio to be hedged replicates the underlying of the futures contract. In other words, it is unrealistic to assumed that the variance of futures returns equals the covariance between spot and futures returns. This will be explained further when we discuss the static hedging model concerning the naïve hedging in the following section.

2.4.2.2. Profit maximisation

The Working's (1953) theory of hedging assumes that hedgers are risk taker, rather than a risk averse. That is, the aim for hedging is to profit from the basis, the price difference between spot and futures prices, rather than to reduce risk although this may be an incidental effect.

2.4.2.3. Portfolio optimisation

A more popular view is the portfolio optimisation approach which was pioneered by Johnson (1960) and Stein (1961). Ederington (1979) argues that portfolio optimisation approach is superior to both the risk minimisation and the profit maximisation because both approaches as the objectives of hedging are considered. He observes that hedging a spot position using futures contracts is synonymous with the construction of a two-asset portfolio: the spot position and the futures contract, whereby the most optimal hedge ratio, b_t^* is given by:

$$b^* = \sigma_{sf} / \sigma_f^s \tag{II.3.3}$$

where, σ_{sf} is the covariance between spot and futures prices, σ_f^2 the variance of futures prices. Consequently, an efficient frontier of expected return and risk can be found by this portfolio for a wide range of risk aversion parameters. If the trader's risk aversion parameter is zero (infinite), the profit maximising (risk minimising) solution is obtained (Sutcliffe 2006, p.257).

2.4.3. Estimating optimal hedge ratios

There are two integrally related questions that should be tackled together with regard to futures hedging. First, how to estimate the number of futures contracts optimally i.e. the optimal hedge ratio. Second, how to measure the effectiveness of the hedging strategy. To estimate the optimal ratio, static and dynamic models are widely used. In this section, we discuss these two models. In the following chapter, we discuss the measurement of hedging effectiveness.

2.4.3.1. The static hedging model

In static model, the joint distribution of spot and futures indices is assumed constant through time. Suppose R_t represent the hedged portfolio return at time t:

$$R_t = s_t - b^* f_t \tag{II.3.4}$$

where $s_t = \ln(S_t/S_{t-1})$ and $f_t = \ln(f_t/f_{t-1})$ are spot and futures returns, respectively. b^* is the number of futures contract to be shorted in order to optimally hedge the long position in the spot market. The expected return, $E(R)$ and variance, $Var(R)$ of the hedged portfolio, would therefore, respectively be:

$$E(R) = E(s) - bE(f) \tag{II.3.5}$$

and

$$Var(R) = Var(s) + b^2 Var(f) - 2bCov_{sf} \tag{II.3.6}$$

Assume that a hedger possesses the following mean-variance expected utility function:

$$EU(R) = E(R) - rVar(R) \tag{II.3.7}$$

where r is the investor's coefficient of risk aversion $(r > 0)$. The hedger chooses the portfolio that will maximise $EU(R)$. Substituting Eqs. (II.3.5) and (II.3.6) into Eq. (II.3.7) and the taking the derivative of the resultant expression with respect to b^*, we find:

$$b^* = \frac{2rCov_{sf} - E(f)}{2rVar(f)} \tag{II.3.8}$$

where b^* is the optimal hedge ratio. Further, if futures prices follows a martingale process, i.e., the expected returns of the futures contracts does not depend on the past information, that is $E(f) = f_0$, the above expression would reduce to:

$$b^* = \frac{Cov_{sf}}{Var_f} = \frac{\sigma_{sf}}{\sigma_f^2} \tag{II.3.9}$$

The optimal hedge ratio, b^* could conveniently be estimated by regressing spot return against futures return, hence it is also known as the OLS hedge ratio.[23] One advantage of the OLS hedge ratio is that it takes into account the imperfect correlation between futures and spot returns.

In naïve hedging, however, the hedge ratio is unrealistically assumed one. That is a hedger takes equal but opposite positions in spot and futures. To see this, we substitute, b^* from Eq. (II.3.9) into the variance of the hedged portfolio, Eq. (II.3.6) and rearranging yields:

$$\begin{aligned} Var(R) &= Var(s) + \left[\frac{Cov_{sf}}{Var_f}\right]^2 Var(f) - 2\left[\frac{Cov_{sf}}{Var_f}\right] Cov_{sf} \\ &= Var(s) - \frac{\left(Cov_{sf}\right)^2}{Var(f)} \\ &= Var(s) - \frac{\left(Cor_{sf}\right)^2 Var(s)Var(f)}{Var(f)} \\ &= Var(s)\left[1 - (\rho_{sf})^2\right] \end{aligned} \tag{II.3.10}$$

where ρ_{sf} is the correlation coefficient between the returns on the spot and the futures. Clearly, a perfect hedge is only achievable with a perfectly positive correlation between futures and spot returns.[24]

[23] Also known as the traditional, conventional or minimum-variance hedge ratio.

[24] However, one-to-one hedge ratio may be optimal for long duration hedges especially in developed markets such as the US (Chen et al. 2004).

2.4.3.2. The dynamic hedging model

In a dynamic hedging model, relevant conditioning information are taken into account in deriving the optimal hedge ratio. Alternatively, the joint distribution of spot and futures returns is assumed time-varying not constant. Suppose the returns at time t on a hedged portfolio consisting of one long unit of spot holdings and b short units of futures contracts at period t is given by (see for example, Kroner & Sultan 1993):

$$R_t = s_t - b^*_{t-1} f_t \tag{II.3.11}$$

where s_t and f_t represent the spot and futures prices changes for time $t-1$ to t, respectively, and b^* represents the number of futures contracts bought at time $t-1$. Similarly, we assume that the investors at each time t would maximise the mean-variance expected utility function:

$$EU\left(R|\Omega_{t-1}\right) = E\left(R_t|\Omega_{t-1}\right) - rVar\left(R_t|\Omega_{t-1}\right) \tag{II.3.12}$$

The utility maximising hedge ratio at time $t-1$, in a mean-variance framework is therefore:

$$b^*_{t-1} = \frac{Cov_{sf}|\Omega_{t-1}}{Var\left(f|\Omega_{t-1}\right)} - \frac{1}{2r}\frac{E\left(f_t|\Omega_{t-1}\right)}{Var\left(f_t|\Omega_{t-1}\right)} \tag{II.3.13}$$

Again, the above expression reduces to Eq. (II.3.14), if the futures prices follow a martingale process:

$$b^*_{t-1} = \frac{Cov_{sf}|\Omega_{t-1}}{Var\left(f_t|\Omega_{t-1}\right)} = \frac{\sigma_{sf}|\Omega_{t-1}}{\sigma^2_f|\Omega_{t-1}} \tag{II.3.14}$$

Thus, in contrast to the static hedge ratio in Eq. (II.3.9), the dynamic hedge ratios in Eq. (II.3.14) are conditioned on the information, Ω_{t-1} as it arrives.

Given the advantages of dynamic over static hedge, three widely known multivariate GARCH models are used in this study to estimate the time-varying hedge ratio. These models and the criterions to evaluate the effectiveness of a hedging strategy are discussed in the Methodology section. For now, let us review the empirical evidence concerning the effectiveness of hedging spot position using index futures.

2.4.4. Empirical evidence

Early studies adopted the constant or traditional OLS model (see for example, Figlewski 1984; Figlewski 1985). However, this model has been subject to many criticisms.

First, there are some statistical problems in OLS regression, in particular, the possible presence of autocorrelation and/or heteroskedasticity in the residuals which may yield biased estimates of optimal hedge ratio causing it to be unreliable. To address this issue, numerous studies use ARMA and/or GARCH specifications in estimating the optimal hedge ratio.

Second, the use of OLS ignores the short-run and long-run dynamic between futures and spot prices/returns which lead to misspecification. Ghosh (1993b) argues that the cointegration relationship (see Engle 1987) between futures and spot prices should be taken into account in order to estimate unbiased hedge ratios. By incorporating the cointegration relationship between S&P500 futures and the underlying for the period from 1990 to 1991, Ghosh (1993b) find higher hedge ratio in comparison to the bivariate OLS without ECM.

Using weekly Nikkei 225 data for 1989 - 1994, Chou, Denis & Lee (1996) find the hedging effectiveness of the ECM model is 2% better than the OLS model. This finding is concurred by Lien & Tse (1999), in their study for the period from 1989 to 1997. In addition they suggest that ECM with GARCH is the best approach. It is worth noting, however that the exclusion of the cointegration relationship between futures and spot should have minimal effect on hedging effectiveness evaluation (Lien 2004).

Finally, the assumption that the variance of futures prices and the covariance between spot and futures prices are equal and hence constant hedge ratio throughout the duration of a hedge is unrealistic as it ignore all relevant conditioning information. Thus a dynamic hedge ratio is deemed to be more realistic.

Numerous studies compare the performance of a hedging strategy using futures by utilising several methods for estimating the hedge ratios. In general, it is found that the dynamic models are superior compared to the static model.

For example, in Canada, Gagnon & Lypny (1997) utilise weekly TSE35 data for the period from 1987 to 1993. They find that the GARCH(1,1) hedge ratios yields higher hedging effectiveness in comparison to the static OLS and naïve hedge ratios. Using daily data on the FTSE100 from 1985 to 1999, Brooks, Henry & Persand (2002) find that the multivariate VECM-GARCH(1,1) model with BEKK parameterisation is superior in comparison to the naïve hedge.

In Australia, Yang & Allen (2005) use daily data for 1988-2000 of the SPI. They find that for the 20-day hedges, the MGARCH strategy is better than the VAR, ECM and static OLS models.

Olgun & Yetkiner (2011) use standard OLS regression and bivariate GARCH to investigate the optimal hedging strategy using the Istanbul Stock Exchange (ISE)-30 index futures by comparing hedging performance of constant and time-varying hedge ratios under the mean-variance utility criteria. Their empirical results reveal that the dynamic hedge strategy outperforms the static and the traditional strategies.

Choudhry (2003) examine the Nikkei225, Hang Seng, SPI, FTSE100, DAX30 and the JSE Industrial 25 and their associated underlying using daily data for the period from 1990 to 1999. He finds that the GARCH models out-performed the OLS between 1% to 14%. In a subsequent study, Choudhry (2004) investigates hedging effectiveness for the Nikkei 225, SPI and Hang Seng using weekly data for the period from 1990 to 2000.

Similarly, he find time-varying GARCH hedge ratios tend to be more effective than OLS and naïve hedge.

In Greece, Floros & Vougas (2004) consider daily data on the FTSE-ASE 20 and FTSE-ASE Mid 40 futures indices for the period from 1999 to 2001. They find that the hedge ratios estimated by multivariate GARCH exceeded those estimated using OLS, which exceeded those estimated by VECM. Sim & Zurbruegg (2001) utilise daily data on the Kospi 200 for the period from 1996 to 1999. They find that the dynamic model, EC-GARCH(1,3) is more effective than the OLS. Similarly, in Taiwan, Wang & Low (2003) find GARCH(1,1) strategy is about 19% more effective than the OLS hedge using the MSCI Taiwan futures during the period from 1997 to 2000.

Pok, Poshakwale & Ford (2009) is the first study that investigates the hedging effectiveness of index futures in emerging Malaysian market. Using bivariate GARCH(1,1) models, they find that the index futures perform effectively as a hedging instrument albeit the Asian financial crisis and impositions of selective capital control regulations. They conclude that the index futures are as effective as those reported in developed markets.

This study differs from Pok et al. (2009). First, by using new data from 2002 to 2012, we provide new evidence on the hedging performance of the FBM-FKLI index futures.[25] Second, we consider the impact of tick size reduction on the hedging performance of FBM-FKLI index futures. We reiterate that this is important because the introduction of the lower tick directly affects the spot liquidity and in turn on the basis. Consequently, the hedging effectiveness using the FBM-FKLI index futures is conditional on the stability and magnitude of the basis. We are unaware of any studies that have investigated this issue in Malaysia.

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[25] We acknowledge the problem of the global financial crisis in 2008. However, the focus of our study is to examine the hedging effectiveness of the index futures before and after the reduction in tick sizes. That is, we do not evaluate which hedging strategy is the best during the crisis and thus the findings must be interpreted with cautious.

2.5. Hypothesis development

This section discusses the development of our hypotheses.

2.5.1. Tick size and stock trading volume

In a competitive market, the introduction of a lower tick will induce lower spreads because traders will be able to trade at narrower spreads. This is especially true if the stocks were previously constrained by the tick size and when the relative tick size is high. In Bursa Malaysia, Chung, Kim & Kitsabunnarat (2005) find that the tick sizes do impose a significant binding constraint on stock prices. Given that Bursa Securities uses a tick structure that varies with price, even higher priced stocks are constraint by the tick size.[26] Therefore, the large capitalisation stocks that make-up the composite index are most likely to benefit from the tick size reduction. Further, in contrast to other markets, Chung et. al (2005) also find that traders in Bursa Malaysia do not quote larger depth. This implies that the adverse impact on market depth is minimal and hence on traders' willingness to trade. Based on the above, we predict that the reduction of the tick leads to higher spot index trading volume. The null and alternative hypotheses are as follows:

H_0^1: *The reduction of tick size has no impact on spot index trading volume.*
H_a^1: *The reduction of tick size leads to higher spot index trading volume.*

2.5.2. Liquidity and the index futures' pricing efficiency

In similar veins, the unexpected component of the spot trading volume serve to strengthen or improve the pricing efficiency of the index futures if it represents arbitrageurs' trade. Also, the magnitude of mispricing will decrease if the unexpected component of spot trading volume represents trades that exploit stock specific information efficiently. We predict that the lowering of tick size will improve the pricing efficiency of the index futures. First, traders will be able to incorporate stock specific information more efficiently due to lower trading costs after the tick reduction.

[26] For example, in Korea stock exchange, which also uses a tick structure that varies with price, Chung, Kang, & Kim (2011) show that if stock price moves to lower tick size category, the spread would decrease on average from 0.8941 to 0.4542%. They suggest that the tick size for the high-priced stocks should be reduced as it is a significant binding constraint on spreads.

In other words, the ability to trade the underlying reduces the basis (Alexander 2008b, p.67). Secondly, it can be implied that the impact of the lower tick on arbitrageurs' ability and willingness to execute their trades is minimal, given that traders in Bursa Malaysia do not normally quote higher depth for higher tick stocks (K. H. Chung et al. 2005). In addition, the tick size reduction is also effective on the exchange-traded fund, which may further facilitate arbitrageurs in reducing negative mispricing. Thus we test the following hypotheses:

H_0^2 : *The unexpected spot index volume following the tick reduction has no impact on the mispricing.*

H_a^2 : *The unexpected spot index volume following the tick reduction reduces mispricing.*

H_0^3 : *The reduction of tick size has no effect on mispricing.*

H_a^3 : *The reduction of tick size leads to lower mispricing.*

2.5.3. The price discovery of role of index futures

We expect that the tick reduction will improve the spot's speed of adjustment towards equilibrium. The reason is that the constituent stocks are large and are actively traded (Hsieh et al. 2008) and therefore may experience greater reduction in spreads. As a consequence traders are in a better position to exploit stock specific information. If this is the case, the price discovery role of the index futures will improve due to the fact that the ability to trade the underlying more efficiently strengthened the relationship between the spot and futures (Alexander 2008b). This leads us to question whether the tick size reduction improves the price discovery role of index futures. Put differently, does the price of the constituent stocks adjust towards intrinsic value at a higher speed as a result of the reduced tick sizes? Therefore, we hypothesise that the tick size reduction improves the spot index speed of adjustment towards equilibrium level.

H_0^4 : *The reduction of tick size has no significant impact on the spot index speed of adjustment towards equilibrium level.*

H_a^4 : *The reduction of tick size improves spot index speed of adjustment towards equilibrium level.*

2.5.4. The hedging effectiveness of the index futures

For the same reasons as above, we predict that the lower tick improves the hedging effectiveness of the index futures. In particular, the relationship between the spot and futures will strengthened following the tick size reduction. As such, the hedge ratio will be higher post-tick period, consequently the hedging effectiveness of the index futures improves because the success of a hedge strategy relies on the higher correlation between these two indices regardless of methods used to estimate the hedge ratio (Alexander & Barbosa 2007). Therefore, we test the following hypotheses:

H_0^5 : *Hedge ratios estimated for the post-tick period is similar to the pre-tick period.*
H_a^5 : *Hedge ratios estimated for the post-tick period is significantly higher compared to the pre-tick period.*

H_0^6 : *Hedge effectiveness for the post-tick period is similar to pre-tick period.*
H_a^6 : *Hedge performance is significantly greater for the post-tick period in comparison to pre-tick period.*

CHAPTER 3

Data and Methodology

This chapter describes the data and methodology used in this study.

Daily data are collected for the spot, futures and money/debt markets. The sample period is from 2 January 2002 to 31 December 2012 consisting of 2704 observations (adjusted for non-trading days).[27]

Daily observations for the spot include closing prices of the index, trading volume and dividend yield. Trading volume represents the total value (in thousand of Ringgit Malaysia) of the constituent shares traded on a particular trading day. For analysis purposes, this variable is scaled by 1000. Dividend yield is the total actual dividend amount for the index expressed as a percentage of the total market value of the constituent stocks.

For the futures, daily observations include settlement price, the total number of contracts traded and the number of days before the contract expires. The settlement price is a continuous series whereby the first values starts at the nearest[28] contract month until the first business day of the next nearest contract month, a volume weighting calculation between the nearest and the next nearest contract months is applied to the prices until the nearest contract reaches its expiry date, at this point the contract rolls over to the next nearest contract month.[29] Daily trading volume in value (thousand of Ringgit Malaysia) is obtained by the multiplication of the settlement price,

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[27] Observations on non-trading days (if any) i.e. Saturdays, Sundays and public holidays were crossed out by using the Stata® Business Calendar feature. This was done to eliminate data errors which, may contaminate the accuracy of our analysis leading to spurious conclusions.

[28] Similar to previous studies (see for example, Theobald & Yallup 1998; Switzer et al. 2000; Pok et al. 2009), we use the nearest contract month instead of the next nearest contract month continuous series in investigating the relationship between futures and spot.

[29] A detailed description of the futures continuos series, which is compiled by DataStream is accessible at http://extranet.datastream.com/data/Futures/Documents/Datastream%20Product%20Futures%20Continuous%20Series.pdf

contract multiplier and the total number of contracts traded. The contract size is RM50 as per the contract specifications (please refer Table 1.7 on page 16).

Daily data on money and debt market variables include; overnight Kuala Lumpur Interbank Offered Rates (KLIBOR), 3-month T-bill rates and 10-year Malaysian Government Securities (MGS) yield. In addition, we collected monthly 10-year Private Debt Securities (PDS) yield, which was interpolated using the cubic spline[30] method to generate its corresponding daily frequency. KLIBOR is the average interest rate at which deposits are offered between banks in the Malaysian money market. MGS are the coupon-bearing, long-term bonds issued by the Malaysian government, and PDS are debt instruments issued by corporations, which include commercial papers (CPs), bonds, asset-backed securities (ABS) and medium term notes (MTNs), amongst others. For analysis purposes these rates/yields were annualised and continuously compounded.

Our study utilises time series methods. For the first empirical chapter, we use OLS regression to explain daily changes in spot trading volume. That is, we assess whether trading volume is significantly higher after the tick reduction. Next, we decompose the raw trading volume into its expected and unexpected components. Using quantile regression (Koenker & Basset 1978), we assess how the unexpected spot trading volume influence mispricing at differing quantiles taking into account the introduction of the lower tick sizes. In addition, we examine the interaction between the unexpected spot volume and the mispricing using vector autoregression (VAR). This is important because a large mispricing, for example, may influence the level of the unexpected spot volume (Roll et al. 2007).

In our second empirical chapter, we estimate the speed at which both spot and futures returns adjust to equilibrium level. The estimators utilised are based on the partial adjustment model (Amihud & Mendelson 1987). By doing so we are able to justify the impact of the tick reduction on the price discovery role of the index futures. For robustness, the long-term relationship between spot and futures returns is also assessed using vector error correction model (VECM).

[30] Details on the Stata® to perform cubic spline interpolation is accessible at https://ideas.repec.org/c/boc/bocode/s457005.html.

We address the impact of the tick reduction on the hedging effectiveness of the index futures in our third and final empirical chapter. Several multivariate generalised auto-regressive conditional heteroskedasticity (MGARCH) models are utilised to estimate the hedge ratios. This is done by using the residuals from VECM estimated in our second empirical chapter. The performance of the hedge ratios is then evaluated using risk minimisation and utility maximisation criterions.

3.1. First empirical chapter: Lower price increments, index market liquidity and index futures' pricing efficiency

Our first empirical chapter i.e. Chapter 4 attempts to answer research question one. Specifically, we address three hypotheses concerning the impact of lower tick on spot index liquidity and on the pricing efficiency of index futures. We shall next discuss the methodologies and variables used in addressing the relevant hypothesis.

3.1.1. Lower tick and trading volume

For our first hypothesis we employ the following model to examine the impact of the reduction in tick sizes on the daily changes in stock index trading volume (Chordia et al. 2001):

$$\Delta V_t^{spot} = \alpha + \beta_1 \Delta I_t + \beta_2 \Delta T_t + \beta_3 \Delta Q_t + \beta_4 \left| s_t^5 \right| + \beta_5 tick + \beta_6 s^d + \beta_7 s^{d-5} + \sum_{j=1}^{4} \delta_i d_j + \varepsilon_t \qquad \text{(III.1.1)}$$

where V_t^{spot} is the daily spot trading volume (scaled by 1000). The independent variables and their theoretical justifications, as per Chordia, Roll & Subrahmanyan (2001), for explaining the spot index volume are discussed below:

Tick size reduction $(tick)$*:* The key variable is a dummy that equals 1 following the tick size reduction (from 3 August 2009 to 31 Dec 2012) and zero otherwise. A significant positive coefficient indicates that the tick reduction leads to an increase in trading volume.

Interest rates affect the level of trading volume. To control for this, short-term interest rates, term spread yield and quality spread yield are included in the model.

Short-term interest rates (I)*:* Decline in short-term rates, reduces the cost of holding inventory of stocks and the cost of margin trading. As a result demand and supply of equities increases. I_t is the KLIBOR rates to proxy for short-term interest rates.

Term spread (T): Increase in term spread indicates positive market outlook, which may influence investors to reallocate their wealth between equity and bond to maximise their earnings. Trading activities may increase as a result. Term spread is defined as the difference between long-term debt and short-term interest rates. T_t is term spread defined as the daily difference between 10-year MGS and the KLIBOR.

Quality spread (Q)*:* Quality spread is the yield spread corporate and government long term bonds. An increase in quality spread implies higher perceived risk of holding inventory of stocks and thereby may lead to a decline in the liquidity. Q_t is quality spread, the daily difference between 10-year PDS and 10-year MGS. The preceding Δ denotes the daily change in the variable.

Other control variables include the past 5-day absolute spot returns, $|s_t^5|$, to proxy for stock market volatility. Dummy variables s^d, s^{d-5} and d_j are included to proxy for concurrent market performance, momentum effects and daily variations in trading volume, respectively.

Market volatility $(|s_t^5|)$: Numerous studies report of a positive relationship between volume change and absolute price change, both in equity and futures markets (see, Karpoff 1987). This implies that large increases in trading volume may be associated with either a recent large increase or a large decrease in price of the constituents stocks. Sudden recent increases or decreases in prices represents risk of trading in the equity markets, which may deter traders from trading during periods of high stock market volatility (Foster & Viswanathan 1990). Market volatility is proxied by the past five trading-day averages of index daily *absolute* index returns.

Equity market performance (s^d)*:* A dummy variable to proxy for concurrent equity market performance, which takes the value 1 if the concurrent spot index return is positive, and zero otherwise. This dummy variable is included because recent price movements may affect investors' perception, which in turn may influence their portfolio composition. Signed concurrent daily spot returns are used as a proxy for recent market performance.

Momentum effect (s^{d-5})*:* Dummy variable equals one if the past five trading-day of daily spot index returns is positive or zero otherwise. This variable is included in the model due to the fact that most trading strategies, in particular momentum/contrarian accounts for recent price trends. Further, technical analysis techniques also involves past market moves.

Day of the week: Dummy d_j is used to capture the effect of daily variations in trading volume. These dummy variables are included in our model to access whether the day of the week effect on trading volume exists in emerging Malaysian market.[31] The variables for our first hypothesis are listed and briefly summarised in Table 3.1 below.

[31] Brooks & Persand (2001) find significant positive Monday average returns and significant negative Tuesday returns in emerging Malaysian market. However, we are unaware of any studies that have examined day of the week effect on volume in emerging Malaysian market.

Table 3.1: Data description for hypothesis one

First empirical chapter (Hypothesis one): The impact of tick size reduction on stock market trading volume		
Variable	Description	Source
Dependent variable		
V_t^{spot}	Daily stock market trading volume represents the total value of constituent stocks traded on a particular trading day, expressed in thousands of Ringgit Malaysia (RM). For analysis purposes, this variable is scaled by a thousand.	Datastream
Independent variables		
$tick$	Dummy variable equals 1 following the implementation of the tick size reduction i.e. 3 August 2009 and 0 otherwise.	-
I_t	The daily Kuala Lumpur Interbank Offered Rates (KLIBOR)[a] as a proxy for short-term interest rates.	Datastream
T_t	Term spread defined as the daily difference between 10-year Malaysian Government Securities (MGS)[b] yield and KLIBOR.	Datastream
Q_t	Quality spread defined as the daily difference between 10-year Private Debt Securities (PDS)[d] yield and 10-year MGS.	Datastream/Bloomberg
s^d	Dummy variable to proxy for concurrent stock market performance, which takes the value 1 if the concurrent spot index return is positive, and zero otherwise.	-
s^{d-5}	Dummy variable equals one if the past five trading-day of daily spot index returns is positive or zero otherwise. This variable is included in the model due to the fact that most trading strategies, in particular momentum/contrarian accounts for recent price trends.	-
$\lvert s_t^5 \rvert$	The past five trading-day moving average of daily absolute spot index returns to proxy for stock market volatility.	Datastream
d_j	Dummy variable to capture the effect of daily variations in trading volume.	-

[a] KLIBOR is the average interest rate at which term deposits are offered between prime banks in the Malaysian wholesale money market.
[b] MGS are the coupon-bearing, long-term bonds issued by the Malaysian government.
[d] PDS are debt instruments issued by corporations, which include commercial papers (CPs), medium term notes (MTNs), bonds, asset-backed securities (ABS), amongst others. For analysis purposes these rates/yields are annualised and continuously compounded.

Table 3.1 shows the correlation coefficients between the explanatory variables. The coefficients are somewhat low or negative which suggests that multicollinearity is not a significant problem.

Table 3.1: Correlation matrix: explanatory variables for daily changes in spot trading volume

	ΔI_t	ΔT_t	ΔQ_t	$\lvert s_t^5 \rvert$
ΔI_t	1	-	-	-
ΔT_t	-0.3117	1	-	-
ΔQ_t	-0.0503	-0.6715	1	-
$\lvert s_t^5 \rvert$	-0.0344	0.0272	0.0045	1

The model is fitted using ARMA (2,2) to account for autocorrelation and due to the presence of ARCH effect, GARCH (1,1) is fitted to account for the conditional variance.

Modelling diagnostic indicates that the residuals from the estimated model are of white noise as shown in Fig. 3.1 below.

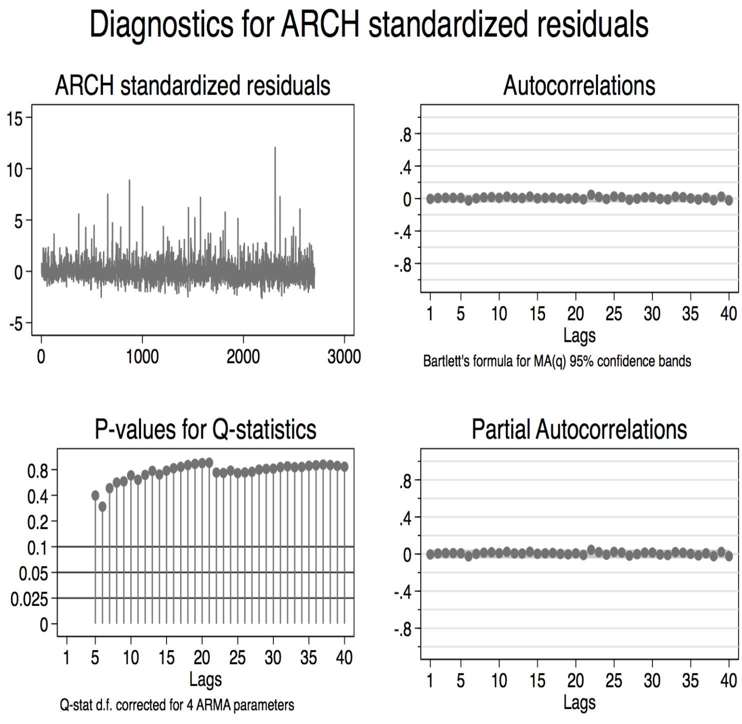

Fig. 3.1: Diagnostics for ARCH standardised residuals (Eq. (III.1.1))

3.1.2. Lower tick, trading volume and index futures' pricing efficiency

This section describes the methodology used to address our second and third hypotheses, which address whether the liquidity improves the pricing efficiency of the index futures.

3.1.2.1. Decomposition of spot trading volume

In order for us to investigate the impact of liquidity on the inter-market relationship between the spot and futures indices, we need to decompose the raw spot trading volume into its expected and unexpected components. We shall focus on the unexpected component because it may represents trades that serves to widen or narrows down the mispricing (see, Cummings & Frino 2011). On one hand, the unexpected spot volume may strengthen the inter-market relationship if it represents arbitrage trading. On the other hand, the mispricing may widen if the unexpected spot volume represents trading to exploit both firm-specific and market-wide information, whenever futures are slower to respond to both type of information (Sutcliffe 2006; Cummings & Frino 2011). Following Bessembinder & Seguin (1992), we decompose the raw spot index volume by first generating a 100-day moving averages. Next, the raw trading volume series is de-trended by deducting the 100-day moving averages. Finally, the de-trended series is segregated into its expected and unexpected components using ARMA(1,3)[32] specification determined using the autocorrelations and partial autocorrelation functions. The sums of constant and predicted residuals represent the unexpected spot index volume, V_t^{sX}.

The index futures volume are also decomposed using similar method as above using ARMA(1,7) specification. The unexpected futures volume is then used as a control variable.

[32] We use ARMA specification because we first detrended the raw series by deducting a 100-day moving average generated from the raw spot volume. The detrended series is stationary. However, ARIMA specification may be use directly to the raw spot volume to decompose the series into expected and unexpected components given that the raw spot volume is non-stationary. The sums of constant and predicted residuals represent the unexpected spot volume. Thus, both methods (ARMA and ARIMA) can be used to decompose the raw trading volume.

3.1.2.2. Computation of the mispricing

As noted earlier (please refer page 26), the cost of carry model links the spot and futures prices. Thus, the intrinsic futures price at time t , F_t^* is estimated as follows:

$$F_t^* = S_t e^{(r-d)(T-t)} \tag{III.1.2}$$

where S_t is the observed price of the spot at time t , r is the risk-free interest rate as proxied by the daily continuously compounded yield on the 3-month T-Bill rate, d is the actual dividend yield[33] (continuously compounded) on the stock index portfolio, and $(T-t)$ is the index futures' number of days to expiration.

Similar to previous studies (see for example, Park & Switzer 1995; Kurov & Lasser 2002; Roll et al. 2007; W.-P. Chen et al. 2009) we define mispricing as the difference between the observed futures price and its intrinsic price, deflated by the observed spot price at time t as follows:

$$M_t^S = \frac{F_t - F_t^*}{S_t} \tag{III.1.3}$$

The index futures are overpriced if the mispricing is positive and vice versa. Conversely they are considered to be efficiently priced if there is no mispricing i.e. $M_t^s = 0$. The above measure of mispricing i.e. M_t^S is implied by the spot market. For robustness, the mispricing as implied by the futures market is also estimated. It is given as the difference between the intrinsic spot price i.e. $S_t^* = F_t e^{-(r-d)(T-t)}$ and the observed spot price S_t , deflated by the spot price at time t as follows:

$$M_t^F = \frac{S_t^* - S_t}{S_t} \tag{III.1.4}$$

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[33] Switzer et al., (2000) have shown that failure to use actual dividend of the constituents stocks that make-up the index could lead to measurement error in the cost-of-carry model. Thus, it is important to obtain the actual dividend yield in calculating the index futures intrinsic value.

The absolute mispricing for both measures are considered because either positive or negative mispricing are costly for investors (Park & Switzer 1995). In this study, the focus is on mispricing and not arbitrage opportunity. That is, we assess the impact of the tick reduction on the pricing efficiency of the index futures. Transaction cost is therefore not taken into account.

3.1.2.3. Unexpected spot trading volume and index futures' pricing efficiency

In examine the impact of the unexpected spot volume on mispricing, we use OLS and quantile regression. In addition, we also estimate bivariate VAR because although high liquidity facilitates arbitrage trading, wider mispricing in itself may trigger arbitrage trading and hence on liquidity.

3.1.2.3.1. OLS and quantile regressions

Following Cummings et al. (2011), the impact of the lower tick and the unexpected component of spot trading volume on the mispricing is investigated using the following model.

$$\begin{aligned}\left|M_t^{S/F}\right| &= \beta_0 + \beta_1 tick + \beta_2 etf + \beta_4 crisis + \beta_3 V_t^{sX} + \beta_4 V_t^{fX} + \beta_5 \sigma_t^f + \\ &\quad \beta_6 (V_t^{sX} * tick) + \beta_7 (V_t^{fX} * tick) + \sum_{i=1}^{p} \vartheta_i \left|M_{t-i}^{S/F}\right| + e_t\end{aligned} \qquad \text{(III.1.5)}$$

where, $\left|M_t^{S/F}\right|$ is the daily absolute mispricing based on the spot prices (Eq. (III.1.3)) or the futures prices (Eq. (III.1.4)). The mispricing is computed based on the cost-of-carry model, details of which can be found on page 62. A total of six lags of the mispricing (for both measures) are included in the model, as identified using the partial autocorrelation functions. Table 3.2 on page 65 provides brief description and sources of variables that are used in addressing hypothesis two and three.

The key explanatory variables are the dummy $tick$, the unexpected spot index volume, V_t^{sX} and the interaction between $tick$ and V_t^{sX} i.e $(V_t^{sX} * tick)$. The dummy $tick$ equals one for the period after 3 August 2009, the date when the tick sizes were reduced and zero otherwise. A significant negative coefficient of the dummy $tick$ indicates that the reduction in tick sizes significantly lowers the daily absolute mispricing. The raw trading volume series, V_t^{spot} is decomposed using similar procedure employed by Bessembinder & Seguin (1992). V_t^{sX} represents the unexpected component of spot trading volume which would indicate trades that represents those of the arbitrageurs' and/or trades that facilitate quicker incorporation of stock specific information, both of which help in reducing the mispricing if its coefficient is significantly negative (Cummings & Frino 2011). Likewise, V_t^{sX} minimises the mispricing following the tick size reduction if the coefficient of $(V_t^{sx} * tick)$ is significantly negative.

Other variables that may have significant impact on the mispricing are also included in the model. The control variables are the unexpected index futures volume, V_t^{fx} index futures volatility, σ_t^f and dummies for the introduction of exchange-traded funds, etf and the global financial crisis of 2008, $crisis$.

V_t^{fx} represents the unexpected futures volume which is decomposed from raw futures volume using similar method used to decompose the spot index volume. V_t^{fx} is also interacted with $tick$ dummy i.e. $(V_t^{fx} * tick)$.

Index futures volatility is defined as $\sigma_t^f = |\log F_t - \log F_{t-1}| \sqrt{\pi/2}$ (Bessembinder & Seguin 1992). Given the inherent advantages of trading, index futures are more volatile which in turn may significantly affect the mispricing. Thus, the variable, σ_t^f is included in the model to control for daily movements in the futures market.

The introduction of the ETFs on the 19 July 2007 may have significant impact on the mispricing because it may facilitate traders in executing the cash-leg of an arbitrage strategy. This is true given that exchange traded funds are not restricted by the no short-selling rules. This also implies that traders may be better able to incorporate stock specific information subsequent to the launching of the ETFs. Furthermore, the reduction of tick size is also effective on the exchange-traded-funds that mirror the spot index. The etf dummy equals one for the period from 19 July 2007 to 31 December 2012.

During period of high uncertainty, it is more likely for assets prices to temporarily deviate away from their equilibrium prices. The period characterised by the global financial crisis period spans from 16 January 2008 to 10 March 2009 and so the *crisis* dummy takes value of one during this period and zero otherwise.

Table 3.2: Data description for hypothesis two and three

First empirical chapter (Hypotheses two and three): The impact of the unexpected spot trading volume and tick size reduction on the mispricing		
Variable	Description	Source
Dependent variable		
M_t^F or M_t^S	The mispricing is defined as the price discrepancies between futures and spot markets based on the cost-of-carry model. M_t^S and M_t^F are the mispricing as implied by the spot and the futures market respectively (Please refer page 62 for details on how the mispricing series was computed).	Datastream
Independent variable		
$tick$	Dummy variable equals 1 following the implementation of the tick size reduction i.e. 3 August 2009 and 0 otherwise.	-
etf	This dummy variable is included as a control variable. It equals 1 for the period from 19 July 2007, the date when exchange traded funds (ETFs) was first launched to 31 December 2012 and 0 otherwise.	-
$crisis$	Dummy variable to control for the Global financial crisis of 2008. It equals 1 from 16 January 2008 to 10 March 2009 and 0 otherwise.	-
$V_t^{futures^X}$	Unexpected futures trading volume[a]	Datastream
$V_t^{spot^X}$	Unexpected spot trading volume[a]	Datastream
$\sigma_t^{futures}$	Volatility of futures market[d]	Datastream
$\left(V_t^{futures^X} * tick\right)$	Interaction between tick size dummy and unexpected futures trading volume	Datastream
$\left(V_t^{spot^X} * tick\right)$	Interaction between tick size dummy and unexpected stock trading volume	Datastream

[a] Both series are decomposed using similar procedure employed by Bessembinder & Seguin (1992). Specifically, 100-day moving averages for both trading volume series are generated. Next, the raw trading volume series are de-trended by deducting the 100-day moving averages. Finally, the de-trended series are decomposed into expected and unexpected components using ARMA specification. Specifically, ARMA(1,3) for spot volume and ARMA(1,7) for futures volume. The sum of constant and predicted residual represents the unexpected trading volume.

[d]Defined as $Vol_t^{futures} = \left|\log(F_t) - \log(F_{t-1})\right| \sqrt{\pi/2}$, similar to Bessembinder & Seguin (1992).

The correlation between the unexpected volume of stock index, V_t^{sX}, the unexpected volume of index futures, V_t^{fx} and the volatility of index futures, σ_t^f is minimal suggesting insignificant effects on the standard errors of the regression estimates as shown in Table 3.2 below.

Table 3.2: Correlation matrix for the explanatory variables for mispricing

	V_t^{fx}	V_t^{sX}	σ_t^f
V_t^{fX}	1.0000	-	-
V_t^{sX}	0.2607	1.0000	-
σ_t^f	0.0761	-0.0107	1.0000

The model is estimated by using OLS and quantile regressions (Koenker & Basset 1978) which allows us to observe how the explanatory variables affect the mispricing under various quantiles i.e. θ= 0.99, 0.9, 0.75, 0.5, 0.25, 0.1 and 0.01. The bootstrapping method is used to estimate the quantile regression parameters.[34]

3.1.2.3.2. Vector autoregressions (VARs)

In addition to investigating the impact of the unexpected spot volume on the mispricing, it is also important to assess the causality relationship between the unexpected spot volume and mispricing. This is due to the fact that the magnitude of the deviation from no-arbitrage relationship, may trigger arbitrage trading and hence on liquidity (Roll et al. 2007).

For this purpose, we fit vector autoregression (VAR) method to investigate the dynamic and short-term relationship between the unexpected spot volume and mispricing, which takes the following form:

$$\begin{aligned} |M_t^s| &= \alpha + \sum_{t=1}^{p} \beta V_{t-1}^{sX} + \sum_{t=1}^{p} \beta |M_{t-1}^s| + e_t \\ V_t^{sX} &= \alpha + \sum_{t=1}^{p} \beta V_{t-1}^{sX} + \sum_{t=1}^{p} \beta |M_{t-1}^s| + e_t \end{aligned} \qquad \text{(III.1.6)}$$

[34] We use quantile regression to describe the relationship between explanatory variables at different points in the conditional distribution of the dependent variable. Thus, we would be able to investigate the impact of tick reduction and the unexpected volume on the entire distribution of mispricing, depending on the quantile chosen. The OLS provides only a partial view of the relationship as it considers the impact of the independent variables merely on the conditional mean of dependent variable. Further, quantile regression is more robust to non-normal errors and outliers.

where $\left|M_t^S\right|$ and V_t^{sX} are the absolute mispricing (implied by the spot market) and the unexpected spot trading volume, respectively. Both series are stationary as indicated by the Augmented Dickey-Fuller test. The test statistic for the unexpected spot volume is -52.003, while it is -27.391 for the absolute mispricing. Table 3.6 below shows the correlation matrix between the absolute mispricing and the unexpected spot volume. The correlation is negative and significant at 10% level. This indicates that high liquidity in the underlying market is associated with lower absolute mispricing.

Table 3.6: Correlation matrix for unexpected spot volume, V_t^{sX} and absolute mispricing, $\left|M_t^S\right|$

	$\left\|M_t^S\right\|$	V_t^{sX}
$\left\|M_t^S\right\|$	1.000	
V_t^{sX}	-0.0029	1.000

Note: The coefficient is significant at the 10% level. The p-value is 0.8789.

We use four lags as indicated by the Aikaike Information Criterion (AIC).

Fig. 3.2 shows the roots of the companion matrix. All the eigenvalues lie inside the unit circle, indicating stability in the VAR system.

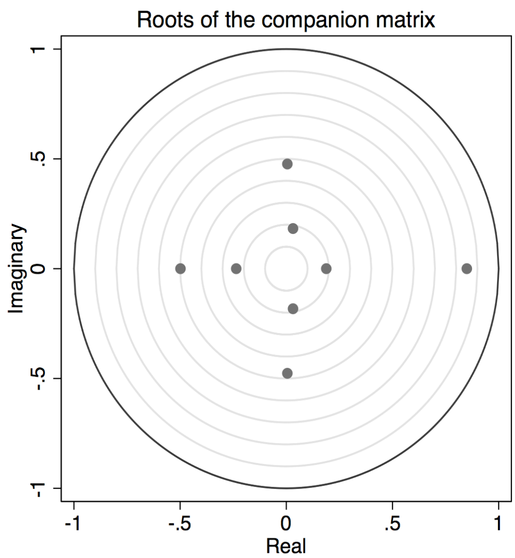

Fig. 3.2: Eigenvalues of the companion matrix for bivariate VAR

Table 3.3 shows the Lagrange multiplier test for autocorrelation for the estimated VAR system. It indicates no significant evidence of autocorrelation. That is, the null of hypothesis of no correlation is not rejected.

Table 3.3: Lagrange-multiplier test for autocorrelation (VAR)

Lag	χ^2	df	$P > \chi^2$
1	4.4698	4	0.34615
2	9.3956	4	0.05194
3	7.231	4	0.12417
4	12.6757	4	0.001297
5	6.2075	4	0.18418
6	2.3507	4	0.67156
7	5.3698	4	0.25141
8	3.1604	4	0.53135
9	1.9296	4	0.7487
10	3.1862	4	0.52716
11	9.585	4	0.04803
12	1.0143	4	0.90761

H_0 : No correlation lag order

3.2. Second and third empirical chapters: Lower tick sizes, price discovery and hedging effectiveness of the index futures

We address our second research question in Chapters 5 and 6. For this purpose, time series of continuously compounded returns were calculated from the prices of the index futures (F_t) and the spot index (S_t) as given by equations $f_t = 100 * [\ln(F_t / F_{t-1}]$ and $s_t = 100 * [\ln(S_t / S_{t-1}]$, respectively. Table 3.3 below provides brief description and sources of these variables.

Table 3.3: Data description for hypothesis four, five and six

Chapter 5 (Hypothesis four): Lower tick and price discovery role of the index futures		
Chapter 6 (Hypothesis five and six): Lower tick and hedging effectiveness of the index futures		
Variable	Description	Source
f_t	Time series of continuously compounded returns calculated from the prices of the index futures, F_t as given by equation $f_t = 100 * [\ln(F_t / F_{t-1})]$	Datastream
s_t	Time series of continuously compounded returns calculated from the prices of the spot index, S_t as given by equation $s_t = 100 * [\ln(S_t / S_{t-1})]$	Datastream

3.2.1. Lower tick and the index futures' price discovery role

In Chapter 5, we assess the price discovery role of the index futures (hypothesis four). The data is divided into pre- and post-tick reduction periods. The pre-tick period runs from 2 January 2002 to 2 August 2009 (1863 observations) and the post-tick period from 3 August 2009 to 31 December 2012 (840 observations). Please refer to Table 5.1 on page 102 for the descriptive statistics.Several methods are employed in assessing the impact of the tick size reduction on the price discovery role of index futures. First, the cross-correlation between futures and its underlying is estimated. Second, the speed of adjustment estimators (Theobald & Yallup 1998; Poshakwale & Theobald 2004), which are based on the partial adjustment model (Amihud & Mendelson 1987), are employed to further assess how fast the return series revert to the equilibrium level. The aim is to investigate how the reduction in tick sizes affects the speed at which both returns series adjust to the equilibrium level. This will enable us to assess the impact of tick reduction on the price discovery role of the index futures. Finally, for robustness, the vector error correction (VECM) model is also estimated.

3.2.1.1. The cross-correlations function

The cross-correlation function is given by:

$$\rho_{fs}(k) = \frac{E\{(f_t - \bar{f})(s_{t\pm k} - \bar{s})\}}{\sigma_f \sigma_s} \tag{III.2.7}$$

where f_t and s_t represent futures and spot returns, respectively. k represents the number of leading or lagging periods. Positive values for the coefficients at leads $k > 0$ will indicate that the futures returns tend to lead those in the stock market, while positive values for the coefficients at lags $k < 0$ will indicate that the stock market tends to lead the futures market. The coefficients at $k = 0$ measures the strength of the contemporaneous relationship.

3.2.1.2. Partial adjustment model

With the cross-correlation function, although the existence of a differential price movement can be confirmed, it does not, however, provide a measure of the magnitude of the differential price movement (Theobald & Yallup 1998). Therefore, we employ the partial adjustment model of Amihud & Mendelson (1987), which is characterised as follows:

$$P_{i_t} - P_{i_{t-1}} = g_i \left\{ V_{i_t} - P_{i_{t-1}} \right\} + u_{i_t} \qquad \text{(III.2.8)}$$

where P_{i_t} is the observed price (in natural logarithm) for the instrument i ($i = s$, for spot or $i = f$, for futures price) at time t, partially adjusts to the intrinsic price, V_{i_t}, which is assumed to follow a random walk with drift process (Amihud & Mendelson 1987), that is:

$$V_{i_t} = \mu + V_{i_{t-1}} + \upsilon_{i_t} \qquad \text{(III.2.9)}$$

g_i is the speed of the adjustment factor, which measures the speed at which the observed price reverts to its intrinsic price. u_{i_t} and υ_{i_t} are the noise (Black 1986) and innovations in the true pricing process. Both are assume to be independently and identically distributed.

Within this modelling framework, the observed price is assumed to partially reflect information, while the intrinsic value is assumed to fully reflect information. Thus, $g_i = 1$ represents full adjustment towards intrinsic price i.e. price incorporates all information, whereas $g_i < 1$ and $g_i > 1$ corresponds to under-adjustment and over-adjustment towards intrinsic price, respectively.

Following existing evidence, it is expected that the futures' speed of adjustment towards equilibrium level is higher and closer to unity in comparison to the spot's adjustment. It is also expected that the reduction of tick sizes would significantly affect the spot's adjustment to equilibrium and in turn on the reliability of index futures as a price discovery tool.

3.2.1.3. Cross-covariance ratio

Based on the partial adjustment model with noise, Theobald & Yallup (1998) demonstrate that the speed of adjustment estimators, for futures, g_f and spot, g_s are given by:

$$1 - g_f = \frac{\text{cov}[f_t, s_{t-1}]}{\text{cov}[f_t, s_t]} \tag{III.2.10}$$

and

$$1 - g_s = \frac{\text{cov}[f_{t-1}, s_t]}{\text{cov}[f_t, s_t]} \tag{III.2.11}$$

where f_t and s_t are futures and spot returns, respectively.

3.2.1.4. The ARMA estimators

In addition, Theobald & Yallup (2004) developed and proposed alternative time series estimators by first differencing and rearranging Eq.(III.2.8) as:

$$R_{i_t} = (1 - g_i)R_{i_{t-1}} + g_i \Delta V_{i_t} + \Delta u_{i_t} \tag{III.2.12}$$

and by substituting for ΔV_{i_t} from Eq.(III.2.9), Eq.(III.2.12) becomes:

$$R_{i_t} = g_i \mu + (1 - g_i)R_{i_{t-1}} + g_i \upsilon_{i_t} + \Delta u_{i_t} \tag{III.2.13}$$

The speed of adjustment are given by the coefficient of AR(1). When $g_i = 1$ i.e. adjustment is complete, "noise" such as bid-ask bounce effects drives the return process.[35]. That is the process will be an MA(1). The speed of adjustment assuming absence of noise and bid-ask bounces effect in the ARMA(1,1) is also estimated.

Further, when thin trading effects are present, Eq. (III.2.13) modifies to:

$$R^m_{i_t} = g_i\mu + (1-g_i)R^m_{i_{t-1}} + \sum_{j=0}^{q}\theta_j L^j\{g_i v_{t-j} + u_{t-j} - u_{t-1-j}\} + (1-(1-g_i)L)R(t) \qquad \text{(III.2.14)}$$

where L^j is the lag operator for *j* steps back. Similarly, the autoregressive coefficient provides an estimate for the speed of adjustment i.e. (1-g_i). Thin trading effects are captured by the moving average component, which is determined by the Aikaiki Information Criterion (AIC).

3.2.1.4.1. Non-random walk intrinsic value process

One of the assumptions of the partial model is that observed prices are assumed to incorporate only a certain portion of market information i.e. there is a delay in price adjustment towards equilibrium value. The equilibrium value or theoretically price, on the other hand is the price that instantaneously and fully incorporates information as it arrives. Amihud & Mendelson (1987) postulates that the intrinsic value process follows a random walk process. In other words, the intrinsic value process is assumed to be informationally efficient.

Poshakwale & Theobald (2004) develop an estimator of the speed of adjustment with the assumption that the intrinsic price may follow other processes. There are a number of reasons that the intrinsic value process may instead follow a mean-reverting process. Futures and spot prices converge at maturity (and hence the basis), implies that prices may have mean reverting characteristics (Theobald & Yallup 2001). In addition, thin trading effects (see for example, Campbell et al. 1997, p.89) and over or under-reaction to information (Barberis et al. 1998) may explain and justify non-random walk processes. Following Poshakwale & Theobald (2004), the underlying process is examined by characterising a process of the form:

[35] The autoregressive component will be stationary only if $|1-g(i)|<1$ i.e. 0< $g(i)$ <2.

$$V_{i_t} = \gamma_i V_{i_{t-1}} + \varepsilon_{i_t} \qquad \text{(III.2.15)}$$

where γ_i is the parameter of the process and ε_{i_t} is the disturbance.[36] $\gamma_i = 1$ indicates that the process is a random walk, while with $\gamma_i < 1$ indicates that the intrinsic value could be a mean reverting process.

By combining Eqs. (III.2.8) and (III.2.15) yields:

$$P_{i_t} - P_{i_{t-1}} = (\gamma_i - g_i)[P_{i_{t-1}} - P_{i_{t-2}}] - g_i(1-\gamma_i)P_{i_{t-2}}) + g_i\varepsilon_{i_t} + u_{i_t} - \gamma_i u_{i_{t-1}} \qquad \text{(III.2.16)}$$

Thus, by estimating $\{g_i, \gamma_i\}$ across futures and spot returns, the impact of differing assumption on intrinsic value process on the partial adjustment factor estimates could be assessed. Hence, conclusion concerning the futures and spot speed of adjustment is technically more robust. Due to non-linearity in the parameter, Eq. (III.2.16) is estimated by non-linear least squares[37].

3.2.1.5. Robustness check: Vector error correction model (VECM)

Based on our analysis of the cross-correlation function and the speed of adjustment estimates, we could clearly determine whether the reliability of the index futures as a source of price discovery improves after the tick reduction. For robustness, however, we also assess the cointegrating relationship between the spot and futures.

Numerous studies indicate that index futures tend to be very highly cointegrated with their underlying prices (Brooks et al. 2001; Roope & Zurbruegg 2002; Alizadeh & Nomikos 2004). The presence of cointegration implies that there is a long term association between their prices. In other words, their prices never drift too far apart, which may be explained by arbitrageurs' trades and the fact that both instruments converge at maturity of the futures.[38] Technically speaking, if spot and futures prices

[36] The inclusion of the drift (intercept) had no major impact on predicted residual, therefore it was excluded.

[37] The equation at Eq. (III.2.16) is stationary whether or not $\gamma(i)$ is equal to unity.

[38] This fact implies that the basis must be mean reverting process (Alexander 2008a, p.201).

are nonstationary but the deviations between them are stationary then spot and futures prices are cointegrated (Engle 1987). In other words, equilibrium relationship exists between futures and spot prices.

Both series are required to be of the same order of nonstationarity to established whether cointegration between the spot and futures exist. We employ the standard augmented Dickey-Fuller test to test for nonstationarity. The result indicates both series are non-stationary. However, after first differencing both series are stationary indicating that the series are integrated of the order one i.e. I(1). Please refer Table 5.1 on page 102.

We could now conduct the cointegration test as we have established that both series are stationary after first differencing, that is the series are integrated of the same order i.e I(1). The cointegration test is to determine whether these two series have a long-run relationship. Given its simplicity and the fact that there could be at most one cointegrating vector, the Engle & Granger (1987) two-steps single equation technique is employed rather than the Johansen & Juselius (1990). The cointegrating regression is given by:

$$\ln S_t = \gamma_0 + \gamma_1 \ln F_t \qquad \text{(III.2.17)}$$

where $\hat{Z} = \ln S_t - \hat{\gamma}_o - \hat{\gamma}_1 \ln F_t$, the residuals from the first stage regression.[39] Next, we test the estimated residuals, $\hat{Z}_t$ for stationarity. The results are displayed in Table 3.4. The relationship between $\ln S_t$ and $\ln F_t$ is strong as indicated by a slope coefficient of 1.001. Also, it is clear that the null hypothesis of non-stationarity in the residuals is rejected. This indicates that there is indeed exists a cointegrating relationship[40], and thus there is a corresponding vector error correction model (VECM).

[39] Alternatively, the cost-of-carry model could be used as the cointegrating regression (see for example, Judge & Reancharoen 2014)

[40] The number of lags in the Engle-Granger regression is determined by the AIC. Inclusion of lags up to 20 does not alter the result.

Table 3.4: Augmented Engle-Granger test for cointegration

Test statistic	1% critical value	5% critical value	10% critical value
-10.42	-3.900	-3.338	-3.046

Engle-Granger 1st-step regression

$\ln S_t$	Coefficient	Standard error	p -value
γ_0	0.767	0.5235	0.143
$\ln F_t$	1.001	0.0004	0.000
Engle-Granger test regression			
$\Delta\hat{Z}_t$			
$\hat{Z}_{t-1}$	-0.206	0.020	0.000
$\Delta\hat{Z}_{t-1}$	-0.403	0.024	0.000
$\Delta\hat{Z}_{t-2}$	-0.223	0.025	0.000
$\Delta\hat{Z}_{t-3}$	-0.174	0.025	0.000
$\Delta\hat{Z}_{t-4}$	-0.069	0.024	0.005
$\Delta\hat{Z}_{t-5}$	-0.079	0.023	0.001
$\Delta\hat{Z}_{t-6}$	-0.057	0.022	0.010
$\Delta\hat{Z}_{t-7}$	-0.059	0.019	0.002

Note: Standard errors are in parentheses.
*Denotes significance at the 1% level.

Following Wahab & Lashgari (1993), the vector error correction model is of the following form:

$$\Delta S_t = \alpha_1 + \alpha_S \hat{Z}_{t-1} + \sum_{i=1}^{n} \alpha_{11}(i)\Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{12}(i)\Delta F_{t-i} + e_{S_t} \qquad \text{(III.2.18)}$$

$$\Delta F_t = \alpha_2 + \alpha_F \hat{Z}_{t-1} + \sum_{i=1}^{n} \alpha_{21}(i)\Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{22}(i)\Delta F_{t-i} + e_{F_t} \qquad \text{(III.2.19)}$$

where S_t and F_t are spot and futures prices, respectively and the preceding Δ denotes the first-difference of the variable. The lagged one-period equiblirium error, $\hat{Z}_{t-1}$ measures the speed at which the left-hand variable reverts to equilibrium level. It also indicates the direction of the causal relationship. For example, if the coefficient for $\hat{Z}_{t-1}$ in Eq. (III.2.18) is zero, then S_t does not respond to previous period's adjustment towards long-run equilibrium. The lagged first differences represent short-run effects of the previous period's returns on the current period's returns. If α_S is zero and all $\alpha_{12}(i)$ are zero in Eq. (III.2.18), then ΔF_t does not Granger cause ΔS_t.

If α_S is zero and all $\alpha_{12}(i)$ are zero, then ΔF_t does not Granger cause ΔS_t. The autoregressive lag length is four as indicated by the Hannan and Quinn's information criterion (HQIC). We use HQIC statistics because it provides consistent estimates of p, the lag length, while AIC statistics tend to overestimate the true lag lenght (Becketti 2012). The number of lags are similar for both pre-and post-tick size reduction. Diagnostic tests indicate no evidence of instability (Fig. 3.3), nor there is evidence of autocorrelated errors (Table 3.5).

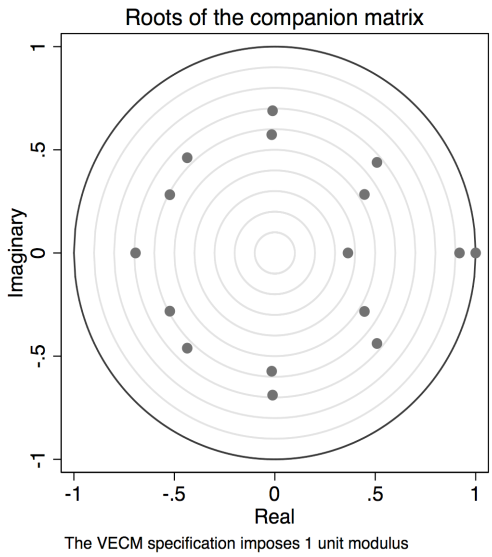

Fig. 3.3: Eigenvalues of the companion matrix for bivariate VECM

Table 3.5: Lagrange-multiplier test for autocorrelation

Lag	χ^2	*df*	$p > \chi^2$
1	2.5261	4	0.6399
2	2.7208	4	0.6055

3.2.2. Lower tick and index futures' hedging effectiveness

The effectiveness of the index futures is assessed in Chapter 6 (hypotheses five and six). The data is divided into in-sample and out-of-sample periods. The in-sample data which runs from 2 January 2002 to 31 July 2012 (2602 observations) is used for estimation, while the out-of-sample data, from 1 August 2012 to 31 December 2012 (101 observations) is for evaluating the performance of the bivariate GARCH(1,1) models considered in this study. The in-sample data is further segregated into pre-tick period, from 2 January 2002 to 2 August 2009 (1863 observations) and post-tick period from 3 August 2009 to 31 July 2012 (739 observations). The descriptive statistics are shown in Table 6.1 on page 112.

To assess the hedging effectiveness of the index futures one has to decide the best method to use for estimating the optimal hedge ratio before any assessment could be made. In this study, three parameterisations of MGARCH model are used to estimate the optimal minimum variance hedge ratios, which are then assessed using risk minimisation and utility maximisation criterions. The hedging effectiveness improves following the tick size reduction, if for example, the percentage reduction in variance is higher in comparison to before the reduction. In addition, we evaluate the out-of-sample hedging effectiveness by using the estimated post-tick period's hedge ratios. This enable us to identify which of those three models performs better in terms of risk reduction and utility maximisation. The following sections discuss the MGARCH models and next, the hedging effectiveness evaluation criterions.

3.2.2.1. Estimation of optimal hedge ratio

The application of autoregressive conditional heteroskedasticity (ARCH) models pioneered by Engle (1982) has been extended to multivariate models owing to the fact that financial volatilities move together over time across assets and markets. That is, many financial variables react to the same information, and hence, covariances between financial variables, conditional on the information set are non-zero. Therefore, the multivariate ARCH models are particularly helpful for financial modelling which require the modelling of both time-varying variances and covariances. One such application is to find the optimal time-varying hedge ratios, the number of futures contracts to be acquired to optimally hedge a risky position in the spot market.

Generally, the joint distribution of spot and futures returns is represented as follow:

$$y_t = \mu + \beta y_{t-1} + \alpha EC + \varepsilon_t ; \varepsilon_t \left| \Omega_{t-1} \sim N(0, H_t) \right. \tag{III.3.20}$$

where $y_t = (s, f)$ is a vector of observations of the spot and futures returns; μ, β and α are column vectors of parameters; EC is the error correction term to account for the long term relationship between the two rates of return; y_{t-1} is a row vector of lagged values of y_t and $\varepsilon_t = (\varepsilon_s, \varepsilon_f)$ is a vector of residuals. ε_t are assumed to be normally distributed and are conditional on past information, Ω_{t-1}, with zero mean vector and with conditional variance-covariance matrix H_t.

Various specifications to model H_t have been proposed.[41] In this study, we utilise three commonly used MGARCH models namely; diagonal VECH; diagonal BEKK and Constant Conditional Correlation (CCC) to estimate the optimal time-varying hedge ratio.

3.2.2.1.1. Diagonal VECH

Bollerslev, Engle & Wooldridge (1988) provide the framework for a multivariate GARCH model. The general bivariate GARCH(p, q) model can be written as:

$$vech(H_t) = vech(C) + \sum_{i=1}^{q} A_i vech\left(\varepsilon_{t-i}\varepsilon'_{t-i}\right) + \sum_{j=1}^{p} B_j vech\left(H_{t-j}\right) \tag{III.3.21}$$

[41] Bauwens, Laurent & Rombouts (2006) provide an excellent survey of multivariate GARCH models.

where ε_t is an $N \times 1$ residuals vector, C is a $1/2\left[N(N+1)\times 1\right]$ vector, A_i ,$i=1,..q$, B_j, $j=1,...,p$, are $1/2\left[N(N+1)\right]\times 1/2\left[N(N+1)\right]$ matrices. When $N=2$ and $p=q=1$, i.e., a bivariate GARCH(1,1) model, the representation above takes the form:

$$vech(H_t)=\begin{bmatrix} h_{11_t} \\ h_{12_t} \\ h_{22_t} \end{bmatrix}=\begin{bmatrix} c_{11} \\ c_{12} \\ c_{22} \end{bmatrix}+\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}\begin{bmatrix} \varepsilon_{1_{t-1}}^2 \\ \varepsilon_{1_{t-1}}\varepsilon_{2_{t-1}} \\ \varepsilon_{2_{t-1}}^2 \end{bmatrix}+\begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}\begin{bmatrix} h_{11_{t-1}} \\ h_{12_{t-1}} \\ h_{22_{t-1}} \end{bmatrix} \quad \text{(III.3.22)}$$

There are, however, two main concerns regarding the specification of H_t above. First, the specification will be difficult to estimate for it has $1/2\left[N(N+1)(N(N+1)+1)\right]$ parameters, which for a bivariate case it adds up to 21 parameters.

Bollerslev, Engle & Wooldridge (1988) used a natural simplification called diagonal representation where A_i and B_j matrices are forced to be diagonal, that is all the entries outside the main diagonal are set to zero.

It is for this restriction that the model is known as a diagonal vech MGARCH model. Subsequently, diagonal bivariate GARCH(1,1) takes the following form:

$$vech(H_t)=\begin{bmatrix} h_{11_t} \\ h_{12_t} \\ h_{22_t} \end{bmatrix}=\begin{bmatrix} c_{11} \\ c_{12} \\ c_{22} \end{bmatrix}+\begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix}\begin{bmatrix} \varepsilon_{1_{t-1}}^2 \\ \varepsilon_{1_{t-1}}\varepsilon_{2_{t-1}} \\ \varepsilon_{2_{t-1}}^2 \end{bmatrix}+\begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix}\begin{bmatrix} h_{11_{t-1}} \\ h_{12_{t-1}} \\ h_{22_{t-1}} \end{bmatrix} \quad \text{(III.3.23)}$$

Each variance h_{ii_t} depends only on its own past squared residuals, $\varepsilon_{i_{t-1}}^2$ and its own lag $h_{ii_{t-1}}$ and each covariance h_{ij_t} depends only on its own past cross products of residuals $\varepsilon_{i_{t-1}}\varepsilon_{j_{t-1}}$ and its own lag $h_{ij_{t-1}}$. In this diagonal bivariate GARCH(1,1) model, the number of parameters to be estimated has been reduced to 9.

3.2.2.1.2. Diagonal BEKK

The other concern in estimating multivariate GARCH model is the requirement that H_t to be positive definite for all values of ε_t.

Engle & Kroner (1995) introduce a positive definite parameterisation known as BEKK parameterisation that ensures the conditional variances are always non-negative.

The BEKK parameterisation for symmetric GARCH(p , q) is:

$$H_t = cc' + \sum_{i=1}^{p} A_i(\varepsilon_{t-i}\varepsilon'_{t-i})A'_i + \sum_{j=1}^{q} B_j(H_{t-j})B'_j \tag{III.3.24}$$

where C, A and B are $N \times N$ parameter matrices and ε_t is an $N \times 1$ residuals vector. When $N = 2$ and $p = q = 1$, i.e., a bivariate GARCH(1,1) model, the representation above takes the following form:

$$\begin{aligned} H_t = \begin{bmatrix} h_{11_t} & h_{12_t} \\ h_{21_t} & h_{22_t} \end{bmatrix} &= \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \end{bmatrix} \\ &+ \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon^2_{1_{t-1}} & \varepsilon_{1_{t-1}}\varepsilon_{2_{t-2}} \\ \varepsilon_{2_{t-1}}\varepsilon_{1_{t-2}} & \varepsilon^2_{2_{t-1}} \end{bmatrix} \begin{bmatrix} a_{11} & a_{21} \\ a_{12} & a_{22} \end{bmatrix} \\ &+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} h_{11_{t-1}} & h_{21_{t-1}} \\ h_{12_{t-1}} & h_{22_{t-1}} \end{bmatrix} \begin{bmatrix} b_{11} & b_{21} \\ b_{12} & b_{22} \end{bmatrix} \end{aligned} \tag{III.3.25}$$

This representation has only 11 parameters. The above system can also be estimated by setting the off-diagonal elements of A and B to zero, i.e., $H_{01} = a_{12} = a_{21} = b_{12} = b_{21} = 0$. This restricted version will be referred to as the diagonal BEKK model.

3.2.2.1.3. Constant Conditional Correlation

Formally, the Constant Conditional Correlations (CCC) MGARCH model derived by Bollerslev (1990) can be written as:

$$H_t = D_t^{1/2} R D_t^{1/2} \qquad \text{(III.3.26)}$$

where D_t is a diagonal matrix of conditional variances:

$$D_t = \begin{bmatrix} \sigma_{1_t}^2 & 0 \\ 0 & \sigma_{2_t}^2 \end{bmatrix} \qquad \text{(III.3.27)}$$

in which each $\sigma_{i_t}^2$ evolves according to a univariate GARCH model of the form:

$$\sigma_{i_t}^2 = s_i + \sum_{j=1}^{p_i} \alpha_j \varepsilon_{i_{t-j}}^2 + \sum_{j=1}^{q_i} \beta_j \sigma_{i_{t-j}}^2 \qquad \text{(III.3.28)}$$

R is matrix of time in-variant unconditional correlations of the standardised residuals:

$$R = \begin{bmatrix} 1 & \rho_{12} \\ \rho_{12} & 1 \end{bmatrix} \qquad \text{(III.3.29)}$$

CCC yield positive definite estimate only if the correlation matrix $\left[\rho_{ij}\right]$ is non-negative and definite. This model is known as the constant conditional correlations MGARCH model because R is time invariant.

3.2.2.2. Hedging efficiency in-sample and out-of-sample

Similar to Pok, Poshakwale & Ford (2009), the optimal hedge ratios computed using estimates obtained from the three hedging models i.e. diagonal VECH, diagonal BEKK and Constant Conditioanal Correlations, are evaluated using risk minimisation and expected utility maximisation criterions.

3.2.2.2.1. The variance reduction comparison

For the risk minimisation criterion, the optimal hedge ratio at time $t-1$ is given by:

$$b_{t-1}^{*} = \frac{\operatorname{cov}(s_t, f_t | \Omega_{t-1})}{\operatorname{var}(f_t | \Omega_{t-1})} \tag{III.3.30}$$

To evaluate the risk reduction before and after the lowering of tick sizes, we calculate the mean, r_{p_t} and the variance, $\sigma_{p_t}^{2}$ of the hedged portfolio (see, Kroner & Sultan 1993), respectively, given by :

$$r_{p_t} = s_t - b_{t-1}^{*} f_t \tag{III.3.31}$$

$$\sigma_{p_t}^{2} = \sigma_{s_t}^{2} + b_{t-1}^{2}\sigma_{f_t}^{2} - 2b_{t-1}^{*}\sigma_{s,f_t} \tag{III.3.32}$$

where s_t is the spot return , f_t is the return of futures at time t and b_{t-1}^{*} is the computed hedge ratios. The percentage reduction in the variance of the hedged portfolio over the unhedged is estimated as follow:

$$\%\Delta = \frac{\sigma_{Hedged}^{2} - \sigma_{Unhedged}^{2}}{\sigma_{Unhedged}^{2}} \tag{III.3.33}$$

where $\sigma_{hedged}^{2} = \sigma_{p_t}^{2} = \sigma_{s_t}^{2} + b_{t-1}^{2}\sigma_{f_t}^{2} - 2b_{t-1}^{*}\sigma_{s,f_t}$ and $\sigma_{unhedged}^{2} = \sigma_{s_t}^{2}$. Obviously, greater percentage variance reduction post-tick period implies that the move of lowering the tick sizes enhanced the usefulness of the index futures as a risk management tool.

In addition, we also study the hedge effectiveness in an out-of-sample comparison for the sake of determining the best hedging model. For this purpose, estimates from the post-tick size reduction period are used to forecast the out-of-sample hedge ratio, which is then used to estimate the hedged portfolio returns and variances using actual or observed spot and futures returns. The model that yields the highest percentage variance reduction is deemed superior in comparison to the other.

3.2.2.2.2. Utility maximization comparison

Under the utility maximisation criterion, the optimal hedge ratio at time $t-1$ is given by:

$$b_{t-1}^{*}=\frac{\operatorname{cov}(s_t,f_t|\Omega_{t-1})}{Var(f_t|\Omega_{t-1})}-\frac{1}{2\lambda}\frac{E(f_t|\Omega_{t-1})}{Var(f_t|\Omega_{t-1})} \qquad \text{(III.3.34)}$$

The risk aversion parameter, λ indicates investor's willingness to trade the futures. For reason of simplicity we assume that the investor's risk aversion parameter equals 1. Likewise, the mean, r_{p_t} and the variance of the hedged portfolio, $\sigma_{p_t}^2$ are respectively calculated as in Eqs. (III.31) and (III.32) above.

Hedging using the index futures is more effective post-tick reduction if the hedge produces higher value of:

$$E\left[U(r_{p_t}^{i}|\Omega_{t-1})\right]=E(r_{p_t}^{i}|\Omega_{t-1})-\lambda\left[(\sigma_{p_t}^{2i}|\Omega_{t-1})\right] \qquad \text{(III.3.35)}$$

The subscript i indicates the type of models used to estimate H_t. An out-of-sample comparison is also carried out to identify the superior hedging model.

CHAPTER 4

First empirical study: Lower tick, spot trading volume and index futures' pricing efficiency

Our first empirical chapter examines the impact of the tick size reduction on the spot index trading volume and in turn on the pricing efficiency of the index futures. The following hypotheses are tested:

H_0^1: *The reduction of tick size has no impact on spot index trading volume.*
H_a^1: *The reduction of tick size leads to higher spot index trading volume.*

H_0^2: *The unexpected spot index volume following the tick reduction has no impact on the mispricing.*
H_a^2: *The unexpected spot index volume following the tick reduction reduces mispricing.*

H_0^3: *The reduction of tick size has no effect on mispricing.*
H_a^3: *The reduction of tick size leads to lower mispricing.*

First, the descriptive statistics of the spot index volume and mispricing are presented and discussed. Next, we discuss the empirical results.

4.1. Descriptive statistics

4.1.1. Trading volume

Fig. 4.1 shows the level of trading volume for both spot and futures markets plotted against the level of prices. Obviously, trading volume for both markets are higher during the financial crisis of 2007/08, however, after the tick reduction, trading activities stabilised with higher trade levels compared to those before the crisis. This seems to be an indication that trading activities are higher after the ticks were reduced.

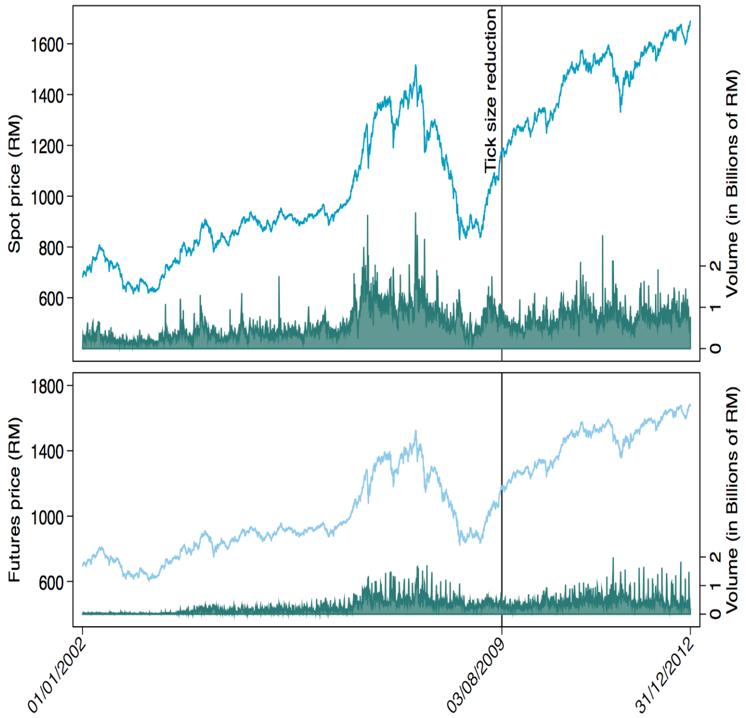

Fig. 4.1: Price and volume for both spot and futures. This figure plots the daily prices on the left-hand scale and daily trading volume (in billions of Ringgit Malaysia)[42] on the right-hand scale for both spot and futures markets. The dark vertical line marks 3 August 2009, the day of the tick rule change.

Table 4.1 provides summary statistics of spot and futures daily trading activities for the pre- and post-tick size reduction periods, as well as for the whole sample period considered in the study. Respectively, panel A and B show the summary statistics for the spot and futures volume (in thousand of Ringgit Malaysia (RM)) traded during a particular trading day. The volume of constituent stocks traded is higher post-tick period. This suggests that the constituents stocks may have benefitted from the reduction in the tick sizes. Similarly, trading activities are higher in the futures market after the lowering of tick sizes. In short, average trading volume for both markets are found to be significantly higher after the lowering of tick sizes. Further, the estimates of standard deviation, σ and coefficient variation, CV for both measures of trading activities are lower for post tick period, which indicates that lower tick sizes have a positive impact on the market. Appendix 4 on page 143 reports summary statistics for the debt market variables.

[42] In order to generate a presentable graph, the raw trading volume for both markets were scaled by a million.

Table 4.1: Descriptive statistics of spot and futures daily trading volume (in thousand of Ringgit Malaysia (RM)[a]

	Pre-tick size reduction	Post-tick size reduction	Whole sample
Panel A: Spot volume			
T	1864	840	2704
Mean	566,505.790	777,680.544[d]	632,107.415
Std. dev. (σ)	413,242.444	279,378.690	389,205.056
CV [b]	0.729	0.359	0.616
Minimum	19,029.00	254,268.00	19,029.00
Maximum	3,300,398.00	2,744,341.00	3,300,398.00
Panel B: Futures volume[c]			
T	1864	840	2704
Mean	247,830.20	464,524.50[d]	315,146.50
Std. dev. (σ)	258,791.40	257,081.00	277,008.30
CV [b]	1.044	0.553	0.879
Minimum	0.000	0.000	0.000
Maximum	1,705,703.00	1,985,066.00	1,985,066.00

[a] The whole sample period is from 2 January 2002 to 31 December 2012. The pre-tick period is from 2 January 2002 to 2 August 2009, and the post-tick period is from 3 August 2009 to 31 December 2012.
[b]The coefficient of variance is calculated as; $CV = \sigma / \mu$.
[c]Futures value (RM) is obtained by the multiplication of contract multiplier, futures price and the number of contracts traded during a particular trading day.
[d] The null hypothesis that the mean spot and futures trading volume are equal for pre- and post-tick reduction is rejected at 1% significance level. The *t*-statistics are -13.4862 and -20.2413 for spot and futures volume respectively.

4.1.2. Mispricing

It is evident that mispricing exists between the spot and futures prices as shown in Fig. 4.2 below. For the period before tick reduction, the mispricing seem to be of large magnitude. Interestingly however, following the tick reduction, it is obvious that the mispricing is lower, more stable and hovers around zero. This indicates an improvement in the pricing efficiency of the index futures. Put differently, the lower tick sizes seem to strengthen the spot-futures relationship regardless of which market the mispricing is implied from.

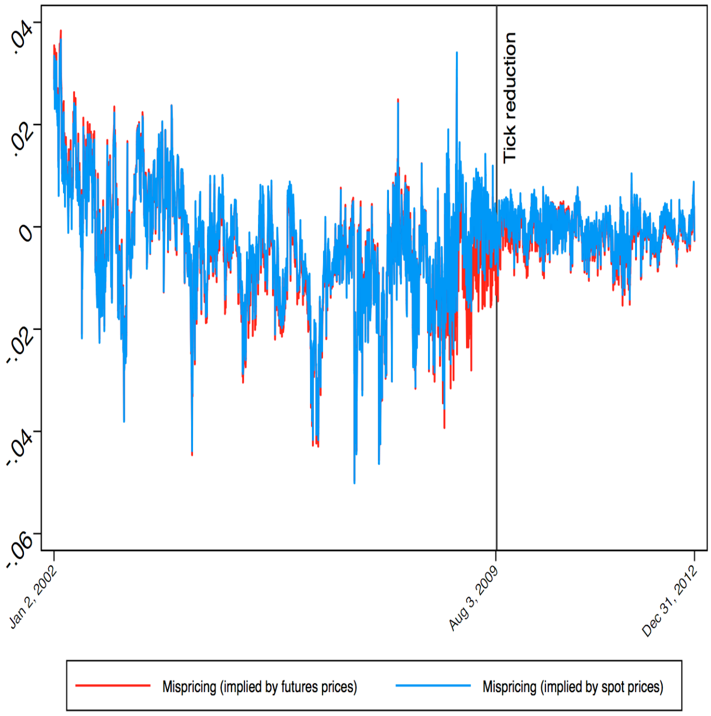

Fig. 4.2 Mispricings series (%): 02 Jan 2002 to 31 Dec 2012

Table 4.2 reports the descriptive statistics of the mispricing. Panel A and Panel B report the (absolute) mispricing as implied by the spot index (Eq. (III.1.3)). In Panel A, the mispricing is significantly lower (-0.05%) for the post-tick period. The first-order autocorrelation of the mispricing series during the pre-tick period is as high as 0.827, indicating high persistence in the mispricing that declines significantly in the post-tick period. Similarly, in Panel B the average absolute mispricing (0.297%) is significantly lower for the post-tick period compared to the pre-tick period (0.994%). Thus, the above suggests that mispricing declines following the lowering of tick sizes. Further, it is interesting to note that the first-order autocorrelation of the changes in mispricing and changes in absolute mispricing are negative throughout the sample period. This provides significant evidence of mean reversion in the series. The mispricing as implied by the index futures (Eq. (III.1.4)) has similar properties as shown in Panel C and D of Table 4.2. Based on that, we conclude that the lower tick sizes improve the index futures pricing efficiency. However, it would be interesting to see how mispricing under various quantiles would be affected by the unexpected spot index volume. The results for the quantiles regression estimates are presented and discussed in the following section.

Table 4.2: Descriptive statistics for the mispricing (%)[a]

Descriptive statistics	Pre-tick	Post-tick	Whole sample
Panel A: M_t^S			
Mean	-0.368	-0.05	-0.269
t-statistic	-13.032[b]	-3.875[b]	-13.409[b]
F-statistic		-7.417[d]	
Standard deviation	1.219	0.371	1.044
First-order autocorrelation	0.827	0.47	0.817
First-order autocorrelation (changes)	-0.351	-0.491	-0.368
Panel B: $\left\|M_t^S\right\|$			
Mean	0.994	0.297	0.777
t-statistic	53.844[b]	37.801[b]	54.114[b]
F-statistic		-24.899[d]	
Standard deviation	0.797	0.227	0.747
First-order autocorrelation	0.702	0.272	0.745
First-order autocorrelation (changes)	-0.376	-0.509	-0.387
Panel C: M_t^F			
Mean	-0.239	-0.083	-0.19
t-statistic	-12.095[b]	-6.827[b]	-13.415[b]
F-statistic		-5.112[d]	
Standard deviation	0.853	0.352	0.738
First-order autocorrelation	0.686	0.309	0.662
First-order autocorrelation (changes)	-0.373	-0.473	-0.389
Panel D: $\left\|M_t^F\right\|$			
Mean	0.662	0.278	0.542
t-statistic	48.523[b]	34.980[b]	52.674[b]
F-statistic		18.259[d]	
Standard deviation	0.589	0.23	0.536
First-order autocorrelation	0.542	0.189	0.571
First-order autocorrelation (changes)	-0.409	-0.526	-0.422

[a] The whole sample period is from 1 January 2002 to 31 December 2012. The pre-tick period is from 1 January 2002 to 2 August 2009, and the post-tick period is from 3 August 2009 to December 2012.

[b] Indicates significant at 1% level.

[d] Indicates average (absolute) mispricing is significantly lower post-tick period at 1% level.

4.2. Estimation results

4.2.1. Trading volume

Table 4.3 reports the ARMA(2,2)-GARCH(1,1) estimation of Eq. (III.1.1) for the scaled spot trading volume (in millions of Ringgit Malaysia). The intercept is significantly negative indicating a considerable decrease in trading volume on Fridays of the week. The day of the week dummies are positive for Tuesday, Wednesday and Thursday, while it is negative for Monday. This suggests that trading volume is lower during the beginning and towards the end of the trading week whereas it is higher during the rest of the days of the week.

The short-term rates and quality spread have negative coefficient signs. However, both apparently have little influence on trading volume. Consistent with the previous studies, the volatility as proxied by the past 5-day absolute index returns is negatively related to daily change in trading volume. That is, high levels of recent volatility are associated with a decrease in trading activity. Most importantly, the coefficient of the tick size dummy is positive and statistically significant at 5% level. This indicates that reduction in tick sizes positively impact the average trading volume in the emerging Malaysian market. Thus, we do not reject the alternative hypothesis that the tick reduction leads to higher spot index trading volume.

Table 4.3: Estimates of daily changes in spot trading volume (in millions of Ringgit)

Variable	Coefficient	Standard error	z	$p > \|z\|$
α	-1.704	5.810	-0.29	0.769
ΔI_t	-49.23	71.26	-0.69	0.490
ΔT_t	15.00	36.38	0.41	0.680
ΔQ_t	-40.75	35.52	-1.15	0.251
$\|s_t^5\|$	-11.16	2.532	-4.41	0.000
s^d	8.922	3.156	2.83	0.005
s^{d-5}	-0.910	2.059	-0.44	0.658
Mon	-31.60	9.002	-3.51	0.000
Tue	18.61	8.789	2.12	0.034
Wed	7.941	8.729	0.91	0.363
Thu	8.566	9.859	0.87	0.385
$tick$	1.594	0.688	2.32	0.020
$AR(1)$	1.251	0.0590	21.22	0.000
$AR(2)$	-0.304	0.0474	-6.41	0.000
$MA(1)$	-1.718	0.0485	-35.42	0.000
$MA(2)$	0.721	0.0476	15.15	0.000
Constant	596.5	57.18	10.43	0.000
$ARCH(1)$	0.161	0.00942	17.13	0.000
$GARCH(1)$	0.857	0.00773	110.77	0.000
T	2,702			

$$\Delta V_t^{spot} = \alpha + \beta_1 \Delta I_t + \beta_2 \Delta T_t + \beta_3 \Delta Q_t + \beta_4 s^d + \beta_5 s^{d-5} + \beta_6 \left|s_t^5\right| + \sum_{j=1}^{4} \delta_i d_j + \beta_6 tick + \varepsilon_t \qquad \text{(III.1.1)}$$

The dependent variable is the daily changes in trading volume (in millions of Ringgit). The model is fitted using ARMA(2,2)-GARCH(1,1) specification. ΔI_t is the short-term rates (Kuala Lumpur Interbank Offered Rate (KLIBOR)). ΔT_t represents the term spread (10-year Malaysian Government Securities (MGS) yield minus KLIBOR rates). ΔQ_t is the quality spread (10-year Private Debt Securities (PDS) yield minus MGS yield). The preceding Δ denotes the daily changes in the variable. These rates/yield are annualised and continuously compounded. $\left|s_t^5\right|$ is the absolute spot returns, to proxy for the market volatility. s^d is the dummy to proxy for concurrent market performance, equals 1 if concurrent spot returns is positive. s^{d-5} is dummy variable to account for momentum effect, equals 1 if the past five trading-day of spot index returns are positive and zero otherwise. d_j is the dummy for day of the week to capture daily variation in trading volume. $tick$ is dummy variable which equals 1 following the implementation of tick size reduction.

4.2.2. Mispricing

4.2.2.1. OLS and quantile regressions

Table 4.4 and Table 4.5 report the results of OLS and quantile regressions for the absolute mispricing series as defined in Eqs. (III.1.3) and (III.1.4), respectively.

In Table 4.4, for the OLS regression, there is a significant evidence of inter-market price discrepancies as reflected by the statistically significant constant term. The lowering of tick sizes seems to reduce the magnitude of this mispricing as indicated by the highly statistically significant $tick$ dummy. Further, it seems that the unexpected spot trading volume represent those trades that reduces the mispricing and this is enhanced following the tick size reduction, as traders are better able to incorporate stock specific information and respond faster to deviation in prices. It is worth noting that significant positive autocorrelation coefficients indicate that the mispricing is persistent (up to lag 4).

For the quantile regressions, we find that the effect of $tick$ at the 99^{th}, 90^{th}, 75^{th}, 50^{th}, 25^{th} ,10^{th} and 1^{st} quantiles are significantly not the same. The coefficients of the $tick$ dummy are significantly negative indicating improvement in pricing efficiency after tick size reduction especially for the larger quantiles i.e. θ>0.5. These results suggest that arbitrageurs are better able to maximise their profit when the mispricing is large as indicated by the highly statistically significant coefficients of the unexpected spot trading volume following the tick size reduction. However, arbitrageurs may find it infeasible to exploit smaller mispricing, for quantile θ<0.5, which may explain the positive coefficients. Robustness checks using mispricing series implied by the futures market indicates identical result as shown in Table 4.5. Thus, it is concluded that the pricing efficiency of index futures improves following the lowering of tick sizes in emerging Malaysian market.

Table 4.4: Tick reduction, liquidity and the mispricing based the spot price, $\left|M_t^S\right|$

	OLS	θ (0.99)	θ (0.9)	θ (0.75)	θ (0.5)	θ (0.25)	θ (0.1)	θ (0.01)
$tick$	-0.091***	-0.391**	-0.402***	-0.176***	-0.017**	0.048**	0.036*	-0.002**
	(0.032)	(0.061)	(0.076)	(0.047)	(0.035)	(0.023)	(0.021)	(0.006)
$crisis$	0.057	0.708***	0.216**	0.112	0.055	0.011	-0.002	-0.005
	(0.037)	(0.261)	(0.096)	(0.085)	(0.060)	(0.050)	(0.024)	(0.016)
etf	-0.026**	-0.002**	0.166**	0.003	-0.063	-0.072***	-0.047**	0.006*
	(0.030)	(0.036)	(0.077)	(0.051)	(0.043)	(0.022)	(0.021)	(0.006)
V_t^{sX}	-0.021**	0.000	-0.000	-0.000	-0.017**	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
V_t^{fX}	0.186***	1.021***	0.414***	0.258***	0.102***	0.065***	0.010	0.001
	(0.024)	(0.132)	(0.043)	(0.047)	(0.025)	(0.023)	(0.015)	(0.007)
σ_t^f	0.061***	0.557***	0.119***	0.063**	0.021	0.003	-0.005	0.005
	(0.020)	(0.126)	(0.044)	(0.029)	(0.018)	(0.011)	(0.011)	(0.004)
$V_t^{fX} * tick$	-0.135***	-0.879**	-0.243***	-0.151**	-0.067**	-0.050*	0.011	-0.002
	(0.044)	(0.414)	(0.073)	(0.070)	(0.032)	(0.026)	(0.022)	(0.009)
$V_t^{sX} * tick$	-0.023**	0.017***	0.000	0.000	-0.011**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\left\|M_{t-1}^S\right\|$	0.361***	0.530***	0.561***	0.500***	0.356***	0.236***	0.107***	0.009
	(0.019)	(0.100)	(0.052)	(0.036)	(0.036)	(0.031)	(0.020)	(0.010)
$\left\|M_{t-2}^S\right\|$	0.189***	0.393**	0.195***	0.202***	0.168***	0.114***	0.086***	0.008
	(0.020)	(0.161)	(0.039)	(0.044)	(0.025)	(0.019)	(0.019)	(0.006)
$\left\|M_{t-3}^S\right\|$	0.046**	-0.016	0.027	0.085*	0.068***	0.065***	0.036	0.009*
	(0.021)	(0.123)	(0.049)	(0.048)	(0.024)	(0.019)	(0.022)	(0.005)
$\left\|M_{t-4}^S\right\|$	0.059***	0.122	0.127**	0.047	0.029	0.039	0.001	-0.005
	(0.021)	(0.111)	(0.050)	(0.037)	(0.036)	(0.024)	(0.022)	(0.005)
$\left\|M_{t-5}^S\right\|$	0.001	0.145	-0.010	0.034	0.035	0.001	0.013	0.004
	(0.020)	(0.174)	(0.039)	(0.036)	(0.037)	(0.019)	(0.017)	(0.009)
$\left\|M_{t-6}^S\right\|$	0.028	0.088	0.061	0.020	0.022	0.016	0.003	0.002
	(0.019)	(0.151)	(0.048)	(0.032)	(0.028)	(0.016)	(0.011)	(0.007)
α	0.177***	0.830***	0.472***	0.292***	0.129***	0.027	-0.002	-0.006
	(0.022)	(0.111)	(0.029)	(0.032)	(0.022)	(0.018)	(0.011)	(0.009)
T	2,691	2,691	2,691	2,691	2,691	2,691	2,691	2,691
R^2	0.406	0.452	0.396	0.312	0.212	0.117	0.052	0.008

Standard errors are in parentheses. "***","**", and "*" represents significance levels of 1, 5 and 10% respectively. The change in average absolute mispricing $\left|M_t^S\right|$ as implied by the spot market (Eq. (III.1.3)) after the reduction of tick sizes is tested by an autoregressive model with six lags, as identified via the partial autocorrelation function, defined in the following equation:

$$\left|M_t^S\right| = \beta_0 + \beta_1 tick + \beta_2 etf + \beta_4 crisis + \beta_3 V_t^{sX} + \beta_4 V_t^{fX} + \beta_5 \sigma_t^f + \beta_6 (V_t^{sX} * tick) + \beta_7 (V_t^{fX} * tick) + \sum_{i=1}^{p} \vartheta_i \left|M_{t-i}^S\right| + e_t \qquad \text{(III.1.5)}$$

$tick$ is a dummy variable which is equal to 1 following the reduction of tick sizes i.e. 3 August 2009. $crisis$ is a dummy variable equals 1 for the period from 16 January 2008 to 10 March 2009. etf is a dummy variable equals 1 from 19 July 2007, the date when exchange traded funds (ETFs) was first launched onwards. V_t^{sX} and V_t^{fX} are the unexpected volume for spot and futures respectively, both of which are also interacted with $tick$ dummy. σ_t^f is the futures volatility. OLS and linear quantile regression (Koenker & Basset 1978)methods are adopted to estimate this equation.

Table 4.5: Robustness check for the mispricing based on futures prices, $\left|M_t^F\right|$.

	OLS	θ (0.99)	θ (0.9)	θ (0.75)	θ (0.5)	θ (0.25)	θ (0.1)	θ (0.01)
$tick$	-0.094***	-0.385**	-0.397***	-0.199***	-0.016**	0.053**	0.032**	0.002**
	(0.031)	(0.055)	(0.080)	(0.074)	(0.040)	(0.025)	(0.022)	(0.009)
$crisis$	0.051	0.769***	0.204	0.100	0.037	0.006	-0.004	-0.009
	(0.037)	(0.289)	(0.135)	(0.095)	(0.045)	(0.034)	(0.026)	(0.014)
etf	-0.020**	-0.009**	0.158**	0.028**	-0.052**	-0.075**	-0.047**	-0.002**
	(0.029)	(0.021)	(0.078)	(0.076)	(0.039)	(0.029)	(0.020)	(0.010)
V_t^{sX}	-0.015**	0.000	-0.000	-0.021**	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
V_t^{fX}	0.187***	1.028***	0.391***	0.263***	0.110***	0.064**	0.034*	0.005
	(0.023)	(0.140)	(0.059)	(0.035)	(0.022)	(0.029)	(0.018)	(0.008)
σ_t^f	0.063***	0.582***	0.135***	0.061**	0.024	0.008	0.011	-0.002
	(0.020)	(0.147)	(0.051)	(0.029)	(0.020)	(0.018)	(0.013)	(0.004)
$V_t^{fX} * tick$	-0.135***	-0.899**	-0.216***	-0.163***	-0.061**	-0.055*	-0.010	-0.005
	(0.044)	(0.386)	(0.068)	(0.055)	(0.026)	(0.031)	(0.024)	(0.009)
$V_t^{sX} * tick$	-0.026***	-0.013***	0.000	-0.017*	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\left\|M_{t-1}^F\right\|$	0.360***	0.561***	0.585***	0.498***	0.362***	0.221***	0.103***	0.005
	(0.019)	(0.150)	(0.046)	(0.056)	(0.034)	(0.025)	(0.020)	(0.013)
$\left\|M_{t-2}^F\right\|$	0.185***	0.386**	0.187***	0.200***	0.167***	0.124***	0.085***	0.015
	(0.020)	(0.177)	(0.039)	(0.044)	(0.026)	(0.022)	(0.016)	(0.009)
$\left\|M_{t-3}^F\right\|$	0.044**	0.009	0.011	0.062	0.053*	0.068***	0.020	0.006
	(0.021)	(0.116)	(0.052)	(0.042)	(0.032)	(0.025)	(0.014)	(0.010)
$\left\|M_{t-4}^F\right\|$	0.069***	0.104	0.126***	0.084**	0.033	0.031	0.008	0.013*
	(0.021)	(0.107)	(0.034)	(0.040)	(0.026)	(0.022)	(0.021)	(0.008)
$\left\|M_{t-5}^F\right\|$	-0.007	0.105	-0.004	0.018	0.037	0.004	-0.004	-0.008*
	(0.020)	(0.167)	(0.059)	(0.028)	(0.029)	(0.017)	(0.024)	(0.005)
$\left\|M_{t-6}^F\right\|$	0.027	0.113	0.049	0.023	0.012	0.016	0.008	0.007
	(0.019)	(0.118)	(0.041)	(0.037)	(0.028)	(0.014)	(0.015)	(0.006)
α	0.175***	0.773***	0.465***	0.291***	0.126***	0.024	0.007	-0.004
	(0.021)	(0.156)	(0.039)	(0.025)	(0.020)	(0.017)	(0.015)	(0.007)
T	2,691	2,691	2,691	2,691	2,691	2,691	2,691	2,691
R^2	0.401	0.456	0.396	0.308	0.203	0.11	0.048	0.011

Standard errors are in parentheses. "***","**", and "*" represents significance levels of 1, 5 and 10% respectively. The change in average absolute mispricing $\left|M_t^F\right|$ as implied by the futures market (Eq.(III.1.4)) after the reduction of tick sizes is tested by an autoregressive model with six lags, as identified via the partial autocorrelation function, defined in the following equation:

$$\left|M_t^F\right| = \beta_0 + \beta_1 tick + \beta_2 etf + \beta_4 crisis + \beta_3 V_t^{sX} + \beta_4 V_t^{fX} + \beta_5 \sigma_t^f + \beta_6 (V_t^{sX} * tick) + \beta_7 (V_t^{fX} * tick) + \sum_{i=1}^{p} \vartheta_i \left|M_{t-i}^F\right| + e_t \qquad \text{(III.1.5)}$$

$tick$ is a dummy variable which is equal to 1 following the reduction of tick sizes i.e. 3 August 2009. $crisis$ is a dummy variable equals 1 for the period from 16 January 2008 to 10 March 2009. etf is a dummy variable equals 1 from 19 July 2007, the date when exchange traded funds (ETFs) was first launched onwards. V_t^{sX} and V_t^{fX} are the unexpected volume for spot and futures respectively, both of which are also interacted with $tick$ dummy. σ_t^f is the futures volatility. OLS and linear quantile regression (Koenker & Basset 1978)methods are adopted to estimate this equation.

4.2.2.2. Vector autoregressions (VARs)

Tables 4.6 and 4.7 report the result of Eq. (III.1.6) for pre- and post-tick periods. The results indicate that the coefficient of the lagged unexpected spot volume is insignificant in explaining absolute mispricing. In the reverse regression of unexpected spot volume on lagged of mispricing, up to three lags of the absolute mispricing are significant in explaining unexpected spot volume. This implies a larger magnitude of deviation from the no-arbitrage relationship may adversely affect liquidity as indicated by the negative coefficients. We now turn to the causal relationship, which allow for a richer dynamic structure between the absolute mispricing and unexpected spot volume.

Table 4.6: OLS regression coefficients (VAR) for the pre-tick period

Panel A: Absolute mispricing as dependent variable, $\lvert M_t^s \rvert$				
Independent variable	Coefficient	Standard error	z	$P>\lvert z \rvert$
$\lvert M_{t-1}^s \rvert$	0.38474	0.02310	16.65	0.000
$\lvert M_{t-2}^s \rvert$	0.17833	0.02475	7.20	0.000
$\lvert M_{t-3}^s \rvert$	0.05399	0.02476	2.18	0.029
$\lvert M_{t-4}^s \rvert$	0.07994	0.02316	3.45	0.000
V_{t-1}^{sX}	0.00007	0.00005	1.19	0.234
V_{t-2}^{sX}	0.00006	0.00005	1.01	0.313
V_{t-3}^{sX}	0.00012	0.00005	2.09	0.037
V_{t-4}^{sX}	0.00000	0.00005	0.06	0.949
Constant	0.19491	0.01913	10.18	0.000
Panel B: Unexpected spot index volume as dependent variable, V_t^{sX}				
Independent variable	Coefficient	Standard error	z	$P>\lvert z \rvert$
$\lvert M_{t-1}^s \rvert$	25.30087	8.95400	2.83	0.005
$\lvert M_{t-2}^s \rvert$	-23.08095	9.59477	-2.41	0.016
$\lvert M_{t-3}^s \rvert$	-26.54056	9.59932	-2.76	0.006
$\lvert M_{t-4}^s \rvert$	6.33711	8.97743	0.71	0.480
V_{t-1}^{sX}	0.04193	0.02317	1.81	0.070
V_{t-2}^{sX}	-0.02765	0.02315	-1.19	0.232
V_{t-3}^{sX}	0.01560	0.02308	0.68	0.499
V_{t-4}^{sX}	0.04391	0.02309	1.90	0.057
Constant	11.60801	7.41744	1.56	0.118

Note: Number of observations is 1861. The pre-tick period is from 2 January 2002 to 2 August 2012.

Table 4.7: OLS regression coefficients (VAR) for the post-tick period

Panel A: Absolute mispricing as dependent variable, $\lvert M_t^s \rvert$				
Independent variable	Coefficient	Standard error	z	$P > \lvert z \rvert$
$\lvert M_{t-1}^s \rvert$	0.12524	0.03456	3.62	0.000
$\lvert M_{t-2}^s \rvert$	0.18804	0.03474	5.41	0.000
$\lvert M_{t-3}^s \rvert$	0.04968	0.03473	1.43	0.153
$\lvert M_{t-4}^s \rvert$	0.04047	0.03451	1.17	0.241
V_{t-1}^{sX}	0.00005	0.00003	1.70	0.090
V_{t-2}^{sX}	0.00004	0.00003	1.18	0.238
V_{t-3}^{sX}	-0.00007	0.00003	-2.05	0.040
V_{t-4}^{sX}	-0.00003	0.00003	-0.89	0.374
Constant	0.16389	0.01643	9.97	0.000
Panel B: Unexpected spot index volume as dependent variable, V_t^{sX}				
Independent variable	Coefficient	Standard error	z	$P > \lvert z \rvert$
$\lvert M_{t-1}^s \rvert$	3.213581	34.89602	0.09	0.927
$\lvert M_{t-2}^s \rvert$	-16.25393	35.08017	-0.46	0.643
$\lvert M_{t-3}^s \rvert$	-29.29285	35.07273	-0.84	0.404
$\lvert M_{t-4}^s \rvert$	-0.06961	34.84765	-0.48	0.632
V_{t-1}^{sX}	-0.06961	0.03448	-2.02	0.043
V_{t-2}^{sX}	0.04111	0.03459	1.19	0.235
V_{t-3}^{sX}	-0.02730	0.03455	-0.79	0.429
V_{t-4}^{sX}	-0.07498	0.03454	-2.17	0.030
Constant	14.17449	16.5912	0.85	0.393

Note: Number of observations is 840. The post-tick period is from 3 August 2009 to 31 December 2012.

Table 4.8 reports the Granger-causality tests between the unexpected spot volume and the absolute mispricing. For the null hypothesis that variable i does not Granger-cause variable j, we test whether the lagged coefficients of i are jointly zero when j is the dependent variable in the VAR. Prior to the tick reduction, the results suggest that unexpected spot volume Granger-cause the absolute mispricing, while the mispricing does not Granger-cause the unexpected spot volume. This indicates that liquidity in the underlying market plays a crucial role in influencing the size of the mispricing. Interestingly, after the tick reduction, the absolute unexpected spot volume Granger-cause the mispricing. Perhaps this is due to the lower trading costs caused by the tick reduction, which enable traders responds to deviation from no-mispricing. Let us now examine the impulse response functions (IRFs) to get a much clearer picture. Fig. 4.3 and Fig. 4.4 show the impulse response functions for the VAR system for the pre- and post-tick periods.

Table 4.8: Granger-causality Wald test for bivariate VAR

Panel A: Pre-tick reduction period (2 January 2002 to 2 August 2009)		
	Absolute mispricing	Unexpected spot volume
Absolute mispricing	-	7.0084
	-	0.135
Unexpected spot volume	21.482	-
	0.000	-
Panel B: Post-tick reduction period (3 August 2009 to 31 December 2012)		
	Absolute mispricing	Unexpected spot volume
Absolute mispricing	-	8.8313
	-	0.065
Unexpected spot volume	1.5987	-
	0.809	-

Note: Null hypotheses: Row variable does not Granger-cause column variable. The cell associated with the i^{th} row variable and the j^{th} column variable shows the χ^2 statistic and the *p*-values (in parentheses) associated with this test.

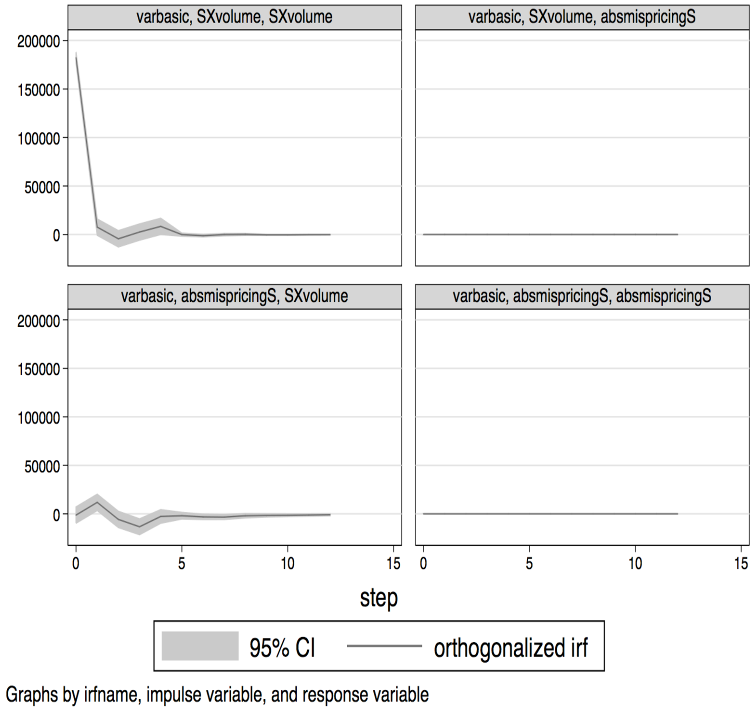

Fig. 4.3: Impulse response functions for the bivariate VAR with the unexpected spot volume and the absolute mispricing (implied by the spot market) for the pre-tick period.

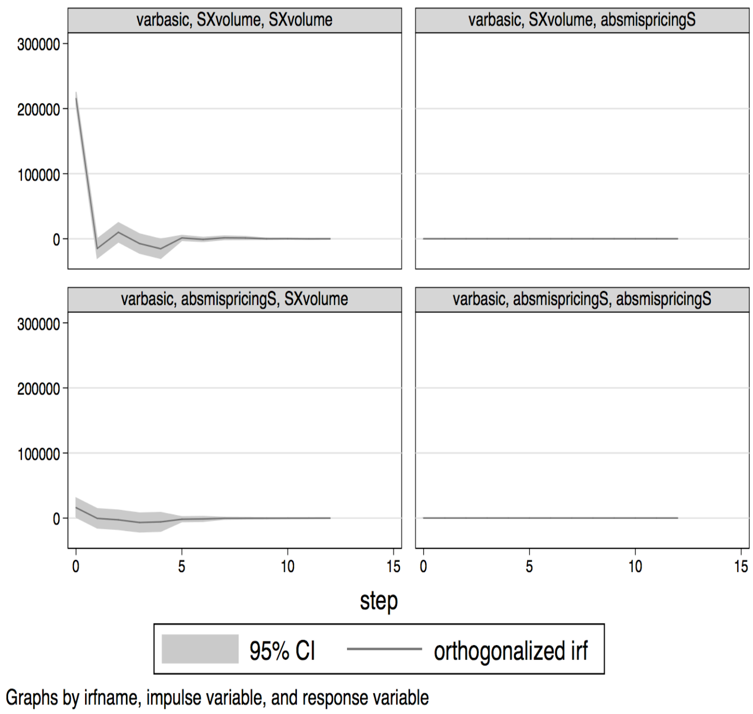

Fig. 4.4: Impulse response functions for the bivariate VAR with the unexpected spot volume and the absolute mispricing (implied by the spot market) for the post-tick period.

4.3. Summary of chapter

In this chapter we assess whether trading volume of the constituent stocks are higher after the lowering of tick sizes. The evidence suggests that trading volume is significantly higher in comparison to pre reduction period. This indicates that the lowering of tick sizes seem to improve liquidity in the underlying stock market. This finding is justified given that the constituent stocks are large and that their prices were previously constrained by the tick size (Chung et al. 2005). This may have enable investors to trade these stocks more efficiently due to higher expected reduction in spreads. As such, the lower tick seems to improve the liquidity of the 30 constituent stocks that make-up the FBM-KLCI spot index in support of our hypothesis. This finding is consistent with Hsieh et al., (2008), where they find the tick reduction in Taiwanese Stock Exchange, a pure order-driven market, improves liquidity, especially for the higher-priced, larger capitalisation and actively traded stocks.

Based on the cost-of-carry model, we compute two series of mispricing which are respectively implied by the spot and futures prices. It is found that mispricing is significantly lower after the tick reduction. This suggests that the lower tick improves the pricing efficiency of the index futures given that the unexpected spot trading volume are found to represent trades that better incorporates stock specific information and those of arbitrageurs' trades. This implies that the tick reduction does not cause the index market to incorporate information ahead of the futures. Further, the finding suggests that arbitrageurs are not adversely affected by possible decline in market depth, especially so traders in Bursa Malaysia do not normally quote higher depth with higher tick. In other words, the introduction of the lower tick sizes facilitate traders to respond quicker to mispricing (Henker & Martens 2005) and incorporate stock specific information more efficiently (Roll et al. 2007). Overall, the evidence suggests that the lowering of tick sizes reduces mispricing between these two markets. Alternatively, the pricing efficiency of the index futures significantly improves following the introduction of the lower tick sizes.

CHAPTER 5

Second empirical study: Lower tick sizes and futures' price discovery role

Our second empirical study focuses on the price discovery of the index futures. The following hypothesis is tested:

H_0^4: *The reduction of tick size has no significant impact on the spot index speed of adjustment towards equilibrium level.*
H_a^4: *The reduction of tick size improves spot index speed of adjustment towards equilibrium level.*

First, the descriptive statistics of the futures and spot returns are presented and discussed. In the following section, we discuss the speed of adjustment estimates for spot and futures returns, pre- and post-tick reduction periods. For robustness, the long-term relationship between the spot and futures is also assessed and presented.

5.1. Descriptive statistics

Fig. 5.1 plots the spot and futures returns for the period from 2 January 2002 to 31 December 2012. The vertical line marks the date 3 August 2009, when the tick sizes were reduced. Both series are less volatile following the tick size reduction and seem to be stationary.

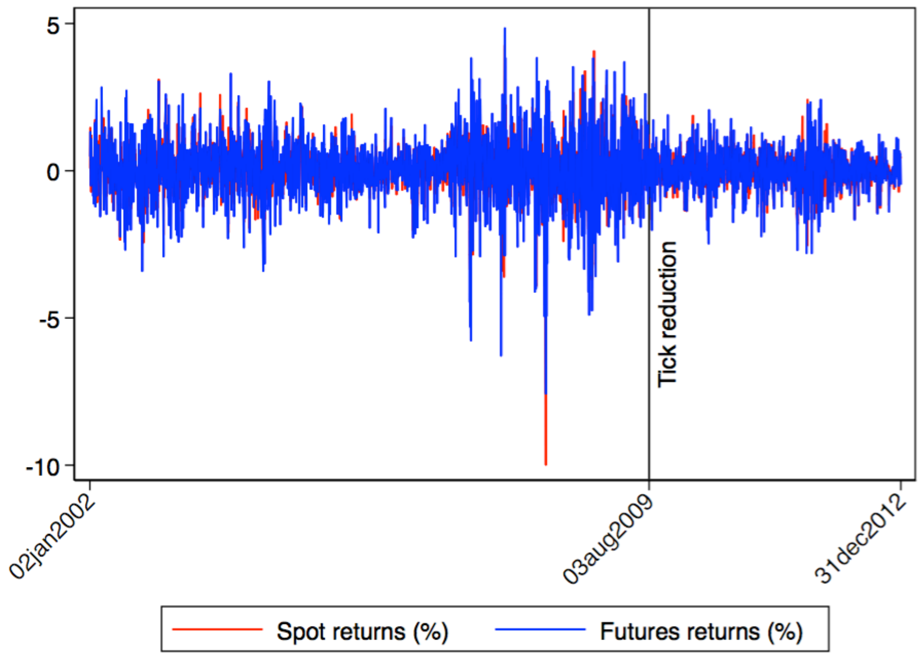

Fig. 5.1: Spot and futures returns for the period from 2 January 2002 to 31 December 2012. The vertical line marks the date when the tick sizes in the spot market were reduced.

Table 5.1 reports the descriptive statistics of spot returns, s_t and futures returns, f_t for the whole as well as for the pre-and post-tick periods. The average returns in the spot market (0.034%) are marginally higher than the average futures returns (0.033%). However, the standard deviation (0.796%) of spot return is lower than the standard deviation (1.018%) of futures return, confirming the higher sensitivity of futures prices to information. Similarly, for the two sub-periods the standard deviations of spot returns are relatively lower than the futures. However, it is worth noting that the volatility of both spot and futures returns are lower in the post-tick period compared to the pre-tick period.

Both returns series exhibit significant first order autocorrelation or higher order autocorrelation in the first 48 lags. Negative autocorrelation in the futures return series is consistent with the bid-ask bounce effect in a traded security, while the effect of non-synchronous trading induces positive autocorrelation in the underlying index return series (Stoll & Whaley 1990). The portmanteau statistics for the squared deviations from the mean reveal evidence of heteroskedasticity throughout the sample period as well as in the sub-sample periods.

It is evident that both returns series are negatively skewed. However, the skewness is lesser for the post-tick size reduction period. Also, the positive kurtosis decreases in the post-tick period. This has significant implications for investors. A reduction in negative skewness with considerable reduction in positive kurtosis indicates a decline in the probability of high negative returns in the post-tick period. Further, for the post-tick period, there is no significant difference in the kurtosis between spot (4.849) and futures (4.669). This suggests that there is no significant difference in the likelihood of abnormal positive or negative spot and futures returns for the period following tick size reduction. In the next section, we discuss the speed at which both returns revert to the equilibrium level.

Table 5.1: Descriptive statistics of the spot index and the index futures returns (%)[a]

Descriptive statistics	s_t			f_t		
	Pre-tick	Post-tick	Whole sample	Pre-tick	Post-tick	Whole sample
T	1863	840	2703	1863	840	2703
Mean	0.029	0.043	0.034	0.028	0.043	0.033
Minimum	-9.979	-2.531	-9.979	-7.565	-2.793	-7.565
Maximum	4.259	2.404	4.259	4.833	2.404	4.833
σ	0.879	0.572	0.796	1.137	0.683	1.018
Skewness	-0.952	-0.449	-0.942	-0.528	-0.370	-0.550
Kurtosis	14.249	4.849	14.991	6.468	4.669	7.246
Jarque-Bera	10103.597	147.841	16592.987	1020.174	116.578	2166.851
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ρ_1	0.133	0.124	0.131	-0.048	-0.068	-0.050
	(0.000)	(0.000)	(0.000)	(0.039)	(0.049)	(0.008)
Q(48)	108.273	82.614	129.423	65.828	64.368	82.210
	(0.000)	(0.001)	(0.000)	(0.045)	(0.057)	(0.002)
$Q^2(48)$	212.822	490.992	386.786	850.170	342.820	1639.553
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ADF	-37.723	-25.668	-45.547	-45.236	-30.960	-54.647
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

[a]The whole sample period is from 2 January 2002 to 31 December 2012. Pre-tick size and post-tick sample periods are from 2 January 2002 to 2 August 2009, and from 3 August 2009 to 31 December 2012, respectively. T is the sample size. σ is the sample standard deviation; ρ_1 is the first-order autocorrelation coefficient; Q(48) is the Ljung-Box portmanteau test for the first 48 lags of the autocorrelation function; $Q^2(48)$ is the corresponding statistic for the squared data; ADF is the Augmented-Dickey Fuller test for stationarity; and JB is Jarque-Bera test of normality, *p*-values are in the parentheses.

5.2. Cross-correlations

The analysis of the summary statistics presented in the previous section offers good indication that the lowering of the tick sizes yields positive impact on the markets. With regard to the relationship between the spot and futures markets, in particular the price discovery role of index futures, we examine the speed at which both markets revert to the equilibrium level before and after the introduction of lower tick size. The aim is to investigate how the speed at which these markets react to new information is affected due to changes in tick rules. Prior to that, we first assess the cross-correlation between spot and futures returns to established the existence of a lead-lag relationship.

Table 5.2 shows the contemporaneous and five-period leading and lagging return cross-correlations between futures and spot returns, for the whole sample period as well as for pre- and post-introduction of lower tick sizes. The contemporaneous cross-correlations are relatively high which suggest that both futures and spot markets possess similar information generating process i.e. they respond to the same underlying information. Consistent with previous studies in the emerging Malaysian market (Pok 2007; Tan 2002), futures leads the spot more strongly than lagging it and that both markets contribute to price discovery. In other words, futures seem to be leading the spot market and that the relationship is not completely uni-directional. Following the tick size reduction, the leading role of futures market has become weaker suggesting that information is more quickly reflected in the underlying spot market which may be attributed to the lower transaction cost caused by the tick size reduction. To investigate this further, the speed of adjustment estimators for both returns series are evaluated and discussed in the following section.

Table 5.2: Cross-correlation structures between futures and spot returns[a]

Lag	Pre-tick	Post-tick	Whole sample
-5	-0.0050	-0.0474	-0.0120
-4	0.0058	0.0084	0.0070
-3	0.0645*	-0.0332	0.0499*
-2	0.0196	0.0632	0.0259
-1	0.0054	0.0306	0.0095
0	0.8047 *	0.7980*	0.8032*
1	0.2069*	0.1983*	0.2057*
2	0.0183	0.0575	0.0242
3	0.0548*	-0.0021	0.0466*
4	0.0506*	0.0067	0.0436*
5	-0.0028	-0.0149	-0.0040

[a] The whole sample frame comprises the period from 2 January 2002 to 31 December 2012. Pre-tick covers the period from 2 January 2002 to 2 August 2009, and post-tick size covers the period from 3 August 2009 to 31 December 2012.
* Significantly different from zero at 5% level.

5.3. Speed of adjustment estimates

There are five estimators of the speed of adjustment factors as presented in the methodology section. The estimates are shown in Table 5.3 for the period before and after the tick size reduction. In this section, we discuss the first four estimators derived assuming that the intrinsic values follow a random walk process. The estimators are: i.) the co-variance ratio; ii.) AR(1); iii.) ARMA(1,1); and ARMA (1,*X*). The fifth speed of adjustment estimator, which assumes non-random walk process is discussed in the subsequent section.

The second column of Table 5.3 reports the cross-covariance estimates of the partial adjustment factor for the futures and the spot markets. The futures seem to adjust to equilibrium level at a higher speed i.e. close to unity in comparison to the spot. However, in the post tick period, the spot adjust to equilibrium level at higher speed compared to the period before the tick was reduced which is an indication that stock specific information are reflected faster in the underlying market.

Columns three to five of Table 5.3 present the estimates of the speed of adjustment using three estimators based on the ARMA specifications. In general, for the whole sample, the results show that the partial adjustment factor for the index futures contract, g_f is significantly higher than for the spot, g_s. Further, the results show that adjustment factors significantly different from one are more frequently evident in the spot market. This implies that, in general, the underlying market under-reacts to information. AR(1) specification assumes absence of spread and noise effects. The findings show that for all the sub-sample periods the index futures incorporate information ahead of stock index. The estimates based on the ARMA(1,1) specification are calibrated assuming an absence of thin trading effect. The findings indicate that when the noise and spread effects are considered, both futures and spot over-react to information. It is noted that the spot adjusts at a considerably lower rate following the tick size reduction. This implies that the tick size reduction has a paramount impact on the spot market given that tick size reduction directly affects the spread.

The ARMA(1,X) specification takes into account the thin trading effect in the underlying. Hence, the estimates for the futures are similar to the ARMA(1,1) specification. The optimal lag order of moving average (X) is based on Akaike Information Criterion (AIC). Similarly, the result suggests that the reduction in tick sizes, facilitate traders in exploiting stock specific information, which strengthens the linkage between stock index and index futures.

Table 5.3: Estimates of adjustment speeds and underlying process[a]

Sample frame	g_i				Non-Random Walk	
	Cross-covariance ratio	AR(1)	ARMA(1,1)	ARMA(1,X)[b]	γ_i	g_i
Whole data set						
g_f	0.988	1.050*	1.305	1.305	1.000**	1.176**
g_s	0.744	0.869*	0.830	0.869*	1.000**	0.721**
Pre-tick						
g_f	0.993	1.048*	1.192	1.192	1.000**	1.182**
g_s	0.743	0.867*	1.134	0.737	1.000**	0.714**
Post-tick						
g_f	0.959	1.068*	1.716*	1.716*	1.000**	1.145**
g_s	0.751	0.876*	0.692	0.876*	1.000**	0.763**

[a] The whole sample frame comprises the period from 2 January 2002 to 31 December 2012; pre-tick period is from 2 Jan 2002 - 2 August 2009 and post-tick is from 3 Aug 2009 to 31 Dec 2012.
[b] The optimal MA components are determined by the Akaike Information Criterion (AIC).
* Statistically significantly different from one at the 5% significance level. Equivalently $(1-g_i)$ is significantly different from zero at 5% level.
**Statistically significantly different from zero at the 5% significance level.

5.4. Speed of adjustment and the underlying process

In the last two column of Table 5.3, we report the estimates of Eq. (III.2.16), which assumes a non-random walk intrinsic value process. The estimates are obtained by using non-linear least squares. Essentially, the intrinsic value process is random walk when the gamma values equals to unity, i.e. the model will be same as ARMA (1, 1).

The results indicate that the speeds of adjustment are higher for the futures similar to those reported in the previous section. In fact, for the futures, it is higher for the whole sample period and in each of the sub-periods. However, the results differ from the previous estimates in that the speed of adjustment for futures are significantly higher than one (over-reaction) and for the spot it is significantly less than one (under-reaction) throughout the whole and for sub-sample periods. This suggests that the speeds of adjustments are sensitive to the specification of the underlying intrinsic value process.

In general, the spot under-react in relation to intrinsic value while futures, in most instances over-react consistent with its price discovery role. With regard to the coefficients in the intrinsic value process, γ_i, there is no evidence of over-or under-reaction for both futures and spot. In general, futures' speed of adjustment is higher and closer to unity in comparison to the spot's speed of adjustment towards intrinsic values. Further, it can be established that the intrinsic values for both markets follow a random walk process.

5.5. Robustness check: Vector error correction model (VECM)

The results of the fitted VECM for pre- and post-tick size periods are displayed in Tables 5.4 and 5.5, respectively. For the pre-tick period, Panel B of Table 5.4 shows that the positive coefficients on ΔF_{t-i} in the spot returns equation are significant. This implies that the spot index moves in the direction of the previous movement of the futures price, underlining the price discovery role of the futures market for the spot market. For the post-tick period, Panel B of Table 5.5, shows that the coefficients on ΔF_{t-i} are positive, however they are insignificant. This indicates that the lead of futures over spot weakens post-tick period. Prior to the tick reduction, error correction mechanism occurs in both futures and spot markets as indicated by the significant coefficient on $\hat{Z}_{t-1}$ for both equations. In comparison, it is significant only in the spot returns equation after the tick reduction. This indicates that following the tick reduction the error correction mechanism is operating primarily through the adjustment of the spot prices rather than the futures prices.

Table 5.4: Causality testing using VECM for the pre-tick reduction period

Panel A: Futures returns as dependent variable

Independent variable	Coefficient	Standard error	z	$P>\|z\|$
$\hat{\varepsilon}_{t-1}$	-0.142	0.0401	-3.54	0.000
ΔF_{t-1}	-0.0765	0.0527	-1.45	0.146
ΔF_{t-2}	-0.00381	0.0538	-0.07	0.943
ΔF_{t-3}	-0.0185	0.0519	-0.36	0.722
ΔF_{t-4}	0.0749	0.0449	1.67	0.095
ΔS_{t-1}	0.116	0.0634	1.83	0.068
ΔS_{t-2}	0.0178	0.0631	0.28	0.777
ΔS_{t-3}	0.106	0.0612	1.73	0.083
ΔS_{t-4}	-0.0662	0.0525	-1.26	0.207
α_2	0.000127	0.000264	0.48	0.630

Panel B: Spot returns as dependent variable

Independent variable	Coefficient	Standard error	z	$P>\|z\|$
$\hat{\varepsilon}_{t-1}$	0.0619	0.0303	2.04	0.041
ΔF_{t-1}	0.247	0.0398	6.22	0.000
ΔF_{t-2}	0.136	0.0406	3.34	0.001
ΔF_{t-3}	0.0939	0.0392	2.40	0.017
ΔF_{t-4}	0.0999	0.0339	2.95	0.003
ΔS_{t-1}	-0.160	0.0479	-3.34	0.001
ΔS_{t-2}	-0.138	0.0477	-2.89	0.004
ΔS_{t-3}	-0.0418	0.0462	-0.90	0.366
ΔS_{t-4}	-0.0919	0.0396	-2.32	0.020
α_1	0.000292	0.000199	1.46	0.143

Note: Number of observations is 1861. The pre-tick period is from 2 January 2002 to 2 August 2012.

Table 5.5: Causality testing using VECM for the post-tick reduction period

Panel A: Futures returns as dependent variable				
Independent variable	Coefficient	Standard error	z	$P>\|z\|$
$\hat{\varepsilon}_{t-1}$	-0.140	0.112	-1.25	0.211
ΔF_{t-1}	-0.195	0.113	-1.72	0.086
ΔF_{t-2}	-0.051	0.108	-0.47	0.637
ΔF_{t-3}	0.037	0.097	0.39	0.699
ΔF_{t-4}	0.076	0.074	1.03	0.304
ΔS_{t-1}	0.240	0.118	2.05	0.041
ΔS_{t-2}	0.104	0.111	0.94	0.346
ΔS_{t-3}	-0.091	0.099	-0.91	0.363
ΔS_{t-4}	-0.043	0.076	-0.56	0.575
α_2	0.000479	0.000241	1.99	0.047
Panel B: Spot returns as dependent variable				
Independent variable	Coefficient	Standard error	z	$P>\|z\|$
$\hat{\varepsilon}_{t-1}$	0.324	0.091	3.55	0.000
ΔF_{t-1}	0.124	0.093	1.34	0.179
ΔF_{t-2}	0.103	0.088	1.17	0.242
ΔF_{t-3}	0.120	0.079	1.52	0.128
ΔF_{t-4}	0.062	0.061	1.02	0.306
ΔS_{t-1}	-0.051	0.096	-0.53	0.596
ΔS_{t-2}	-0.054	0.090	-0.60	0.546
ΔS_{t-3}	-0.181	0.081	-2.22	0.026
ΔS_{t-4}	-0.050	0.063	-0.80	0.424
α_1	0.000207	0.000196	1.06	0.291

Note: Number of observations is 840. The post-tick period is from 3 August 2009 to 31 December 2012.

5.6. Summary of chapter

It is established that the tick size reduction facilitates the incorporation of stock specific information, which explains the weakening of futures lead over spot. In all cases, except for the ARMA(1,1) specification, it is shown that the spot adjust at a higher speed towards their equilibrium prices following the tick reduction period albeit insignificantly. However, our results are consistent with the existing literature suggesting that cash markets do not move as rapidly as futures markets. For robustness, we also estimate the vector error correction model (VECM).

In line with previous studies (Pok 2007; Tan 2002), the results show that futures lead the spot more strongly than lagging it and that both markets contribute to price discovery, that is, the relationship is not completely uni-directional. Interestingly, after the tick reduction, the adjustment towards equilibrium occurs primarily in the spot market indicating positive effects of the tick reduction. This is consistent with existing empirical evidence, which suggests that reduction in tick size improves the reliability of index futures as the bellwether instrument as it allows for better incorporation of stock specific information. For example, in Toronto Stock Exchange, Beaulieu, Ebrahim & Morgan (2003) suggest that tick reduction improves the price discovery role of TSE 35 index futures, which they attribute to the transaction cost hypothesis. The reason is that, the ability to trade the underlying stocks reduces the basis/mispricing (Alexander & Barbosa 2008) and thus improves the price discovery role of index futures (Garbade & Silber 1983). Taken together, these results suggest that the index futures market is a useful price discovery tool and that this is enhanced by the introduction of the lower tick sizes on 3 August 2009.

CHAPTER 6

Third empirical study: Lower tick sizes and futures' hedging efficiency

In this chapter, we investigate the hedging effectiveness of the index futures. As noted earlier, given the inconclusive evidence of the impact of a lower tick size on the stock market liquidity (see for example, Ahn et al. 1996; Ronen & Weaver 2001; Pavabutr & Prangwattananon 2009), and hence on the spot index liquidity, there are possibilities that the lower tick may weaken the relationship between the spot and futures indices. This in turn may adversely affect the performance of a hedging strategy using index futures. The reason is that the underlying liquidity which is directly affected by the lower tick size affects the basis risk[43] (Roll et al. 2007). Hedging on the other hand, transforms price risk to basis risk (Jorion 2007). Consequently, the effectiveness of a hedging strategy relies on the magnitude and stability of the basis (Sutcliffe 2006). Thus, we test the following hypotheses:

H_0^5 : *Hedge ratios estimated for the post-tick period is similar to the pre-tick period.*
H_a^5 : *Hedge ratios estimated for the post-tick period is significantly higher compared to the pre-tick period.*

H_0^6 : *Hedge effectiveness for the post-tick period is similar to pre-tick period.*
H_a^6 : *Hedge performance is significantly greater for the post-tick period in comparison to pre-tick period.*

6.1. Descriptive statistics

We first explore the descriptive statistics of the futures and spot returns as shown in Table 6.1 below. For the whole in-sample period, the average returns in the spot market (0.0335%) are marginally higher than the average futures returns (0.0328%), as it is in the period prior to the lowering of tick sizes (i.e. 0.0291% vs. 0.0278%). However, futures returns (0.0456%) are higher in comparison to the spot’s (0.0444%), subsequent to the tick size reduction. It is worth noting that both markets experience reduced volatility following the tick size reduction.

[43] The risk that the change in futures price over time does not track exactly the changes in the price of the spot.

Spot and futures prices appear to be platykurtic as indicated by the positive kurtosis coefficients. Pertaining to the skewness of returns, before the reduction, it is negative for both spot and futures (-0.952 and -0.528, respectively). The degree of negative skewness and positive kurtosis are however lower in the post-tick reduction period. This has significant implications for investors. A reduction in negative skewness with considerable reduction in positive kurtosis indicates a decline in the probability of high negative returns in the post-tick period. Further, for the post-tick period, there is no significant difference in the kurtosis between spot (4.693) and futures (4.495), which suggests that there is no significant difference in the likelihood of abnormal positive or negative spot and futures returns for the period following tick size reduction. The results imply that the lowering of tick sizes has a positive impact on the equity markets. The Jarque-Bera tests indicate significant departures from normality and the magnitude of departures from normality seem to be quite similar for these two series.

Tests for autocorrelation on the first twelve lags of the sample autocorrelation function is significant indicating that autocorrelation are present in both spot and futures returns. There is also evidence to support the presence of ARCH effect as indicated by the Ljung-Box Q statistic on the squared return series. Therefore, a hedging model that allows for time-varying variances and co-variances may be appropriate. Both return series are I(0) as indicated by the Augmented Dickey-Fuller and Philips-Perron unit root tests. Fig. 6.1 plots the futures and spot prices and returns.

Table 6.1: Descriptive statistics of the spot index and the index futures returns (f)[a]

Descriptive statistics	s			f		
	Pre-tick	Post-tick	Whole in-sample	Pre-tick	Post-tick	Whole in-sample
T	1,863	739	2,602	1,863	739	2,602
Mean	0.0291	0.0444	0.0335	0.0278	0.0456	0.0328
Std. Deviation	0.879	0.591	0.808	1.137	0.708	1.034
Minimum	-9.979	-2.531	-9.979	-7.565	-2.793	-7.565
Median	0.0512	0.0853	0.0576	0.0357	0.0738	0.0561
Maximum	4.259	2.404	4.259	4.833	2.404	4.833
Skewness	-0.952	-0.431	-0.934	-0.528	-0.38	-0.546
Kurtosis	14.25	4.693	14.71	6.468	4.495	7.077
JB test[b]	10103.597	111.154	15237.051	1020.174	86.598	1931.941
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Q(12)[d]	51.733	18.869	63.832	21.981	13.756	28.2
$Q^2(12)$[d]	143.057	191.764	230.558	610.944	121.041	979.329
ADF test[e]	-11.533	-7.784	-13.809	-11.751	-7.683	-13.968
PP test[g]	-38.005	-23.915	-44.943	-45.186	-29.267	-53.596

[a] The whole in-sample period is from 2 January 2002 to 31 July 2012. The in-sample period is divided into pre-tick size reduction period; from 2 January 2002 to 2 August 2009, and post-tick size reduction period; from 3 August 2009 to 31 July 2012. [b]JB test is the Jarque-Bera test for Normality.
[d] Q(12) and $Q^2(12)$ are Ljung-Box tests for twelfth-order autocorrelation in the level and squared series, respectively. [e] ADF test is the Augmented-Dickey Fuller tests. [g]PP test is the Philips and Perron unit root tests. 1%, 5% and 10% critical values for this test are -3.960, -3.410 and -3.120, respectively.

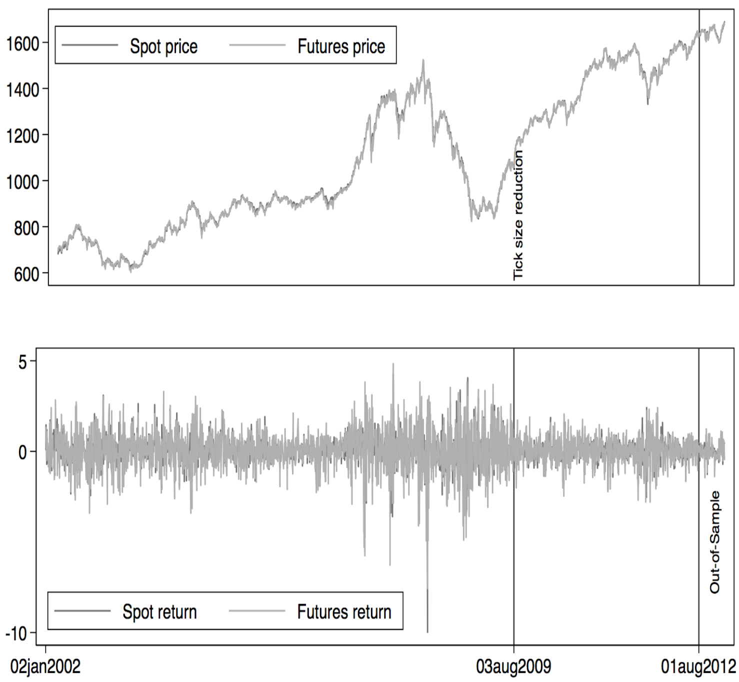

Fig. 6.1: Spot and Futures Prices/Returns: 02 Jan 2002 to 31 Dec 2012

6.2. Model estimation

The results from the maximum likelihood estimation of H_t for the GARCH(1,1) DVECH, DBEKK and CCC models for the overall in-sample and the in-sample sub-periods i.e. pre-tick and post-tick are reported in Table 6.2, Table 6.3 and Table 6.4, respectively.

For the overall in-sample period, the parameters estimated for each of the models are significant in explaining the distribution of spot and futures at the 1% level implying that the distributions of spot and futures returns are time-varying. In terms of the log-likelihood value, the DBEKK dominates the DVECH and CCC. The DVECH also dominates the CCC model. Further we observe that the specifications are covariance stationary.

For the pre-tick period too, all parameter estimates are statistically different from zero for all three models and that the specifications are covariance stationary. The period following the introduction of lower tick size reveals a similar pattern whereby all parameters estimated for the three models are significant at 1% level and that the models are covariance stationary. Next, we discuss the descriptive statistics of hedge ratios estimated from these models under risk minimisation and utility maximisation criterions.

Table 6.2: Maximum likelihood estimation for the overall in sample*

Diagonal VECH				Diagonal BEKK				CCC			
	Coef.	S.E	z-Stat.		Coef.	S.E	z-Stat.		Coef.	S.E	z-Stat.
C(1)	0.0594	0.0126	4.7308	C(1)	0.0536	0.0122	4.3935	C(1)	0.0610	0.0120	5.0692
C(2)	0.0550	0.0159	3.4528	C(2)	0.0478	0.0168	2.8526	C(2)	0.0616	0.0152	4.0547
M(1,1)	0.0206	0.0027	7.6347	M	0.0162	0.0018	9.0734	M(1)	0.0101	0.0015	6.5939
M(1,2)	0.0176	0.0024	7.2521	A1(1,1)	0.3506	0.0085	41.3540	A1(1)	0.0910	0.0059	15.4515
M(2,2)	0.0192	0.0028	6.9527	A1(2,2)	0.2363	0.0066	35.9281	B1(1)	0.8947	0.0072	124.4001
A1(1,1)	0.0947	0.0055	17.2312	B1(1,1)	0.9274	0.0037	249.7961	M(2)	0.0122	0.0020	6.1858
A1(1,2)	0.0652	0.0046	14.2481	B1(2,2)	0.9640	0.0017	558.3558	A1(2)	0.0794	0.0052	15.3354
A1(2,2)	0.0704	0.0051	13.9361					B1(2)	0.9102	0.0055	164.4592
B1(1,1)	0.8682	0.0089	97.4367					R(1,2)	0.7980	0.0062	129.6474
B1(1,2)	0.8999	0.0076	118.3393								
B1(2,2)	0.9081	0.0064	141.2354								
L.likelihood			-4907.5340	L.likelihood			-4973.5300	L.likelihood			-4,923.9580

* The in-sample period is from 2 January 2002 to 31 July 2012.
[a] Significant at 1% level

Table 6.3: Maximum likelihood estimation for the pre-tick reduction period.*

Diagonal VECH				Diagonal BEKK				CCC			
	Coef.	S.E	z-Stat.		Coef.	S.E	z-Stat.		Coef.	S.E	z-Stat.
C(1)	0.0574	0.0163	3.5220	C(1)	0.0497	0.0160	3.0987	C(1)	0.0589	0.0156	3.7663
C(2)	0.0534	0.0216	2.4672	C(2)	0.0453	0.0226	2.0048	C(2)	0.0615	0.0204	3.0155
M(1,1)	0.0283	0.0045	6.3298	M	0.0262	0.0033	7.9678	M(1)	0.0172	0.0029	5.8586
M(1,2)	0.0259	0.0046	5.7005	A1(1,1)	0.3615	0.0104	34.6024	A1(1)	0.1075	0.0081	13.3493
M(2,2)	0.0331	0.0057	5.8045	A1(2,2)	0.2277	0.0074	30.6993	B1(1)	0.8729	0.0105	82.9631
A1(1,1)	0.1008	0.0070	14.3359	B1(1,1)	0.9179	0.0052	176.7057	M(2)	0.0226	0.0038	5.9497
A1(1,2)	0.0672	0.0058	11.5110	B1(2,2)	0.9631	0.0022	438.6339	A1(2)	0.0840	0.0063	13.3292
A1(2,2)	0.0718	0.0060	11.8704					B1(2)	0.8993	0.0070	128.3905
B1(1,1)	0.8575	0.0120	71.3010					R(1,2)	0.7937	0.0078	102.4002
B1(1,2)	0.8910	0.0107	83.2545								
B1(2,2)	0.8983	0.0087	103.5294								
Log likelihood			-3932.2440	Log likelihood			-3976.1480	Log likelihood			-3930.7110

* The pre-tick period is from 2 January 2002 to 2 August 2009
[a] Significant at 1% level

Table 6.4: Maximum likelihood estimation for the post-tick reduction period*

Diagonal VECH				Diagonal BEKK				CCC			
	Coef.	S.E	z-Stat.		Coef.	S.E	z-Stat.		Coef.	S.E	z-Stat.
C(1)	0.0609	0.0208	2.9227	C(1)	0.0570	0.0195	2.9155	C(1)	0.0590	0.0197	2.9868
C(2)	0.0571	0.0246	2.3229	C(2)	0.0516	0.0261	1.9785	C(2)	0.0560	0.0234	2.3923
M(1,1)	0.0394	0.0091	4.3406	M	0.0202	0.0031	6.6096	M(1)	0.0140	0.0039	3.5789
M(1,2)	0.0287	0.0059	4.8694	A1(1,1)	0.3442	0.0200	17.1742	A1(1)	0.0769	0.0107	7.2125
M(2,2)	0.0213	0.0045	4.7500	A1(2,2)	0.2100	0.0171	12.3087	B1(1)	0.8791	0.0191	46.0447
A1(1,1)	0.0956	0.0153	6.2401	B1(1,1)	0.9132	0.0086	106.2615	M(2)	0.0127	0.0039	3.2571
A1(1,2)	0.0582	0.0128	4.5669	B1(2,2)	0.9583	0.0043	220.9837	A1(2)	0.0671	0.0118	5.6918
A1(2,2)	0.0566	0.0114	4.9409					B1(2)	0.9071	0.0151	60.2056
B1(1,1)	0.7834	0.0331	23.6326					R(1,2)	0.8068	0.0108	74.4740
B1(1,2)	0.8518	0.0251	33.9490								
B1(2,2)	0.8994	0.0166	54.1301								
Log likelihood			-955.9869	Log likelihood			-977.7391	Log likelihood			-980.1943

* The post-tick period is from 3 August 2009 to 31 July 2012

[a] Significant at 1% level

6.3. Descriptive statistics of the hedge ratios

Fig. 6.2 plots the time varying hedge ratios under the risk minimisation criterion. The conditional hedge ratios fluctuate as new information arrives. The hedge ratios are somewhat higher post-tick size reduction period indicating higher correlation between futures and spot markets. Indeed, on average the hedge ratio estimates from all three models are higher post-tick period as shown in Table 6.5. Further, except for the estimates from DVECH model, the standard deviation is lower post-tick period, which may indicate positive impact on the equity markets caused by the lower tick size. We note further that ADF and PP unit root tests suggest that for the whole in-sample period and the two sub-periods, the time-varying hedge ratios are I(0), at the 5% level implying that the hedge ratios are mean reverting. The hedge ratios under the utility maximisation criterion yield similar observations as shown in Table 6.6.

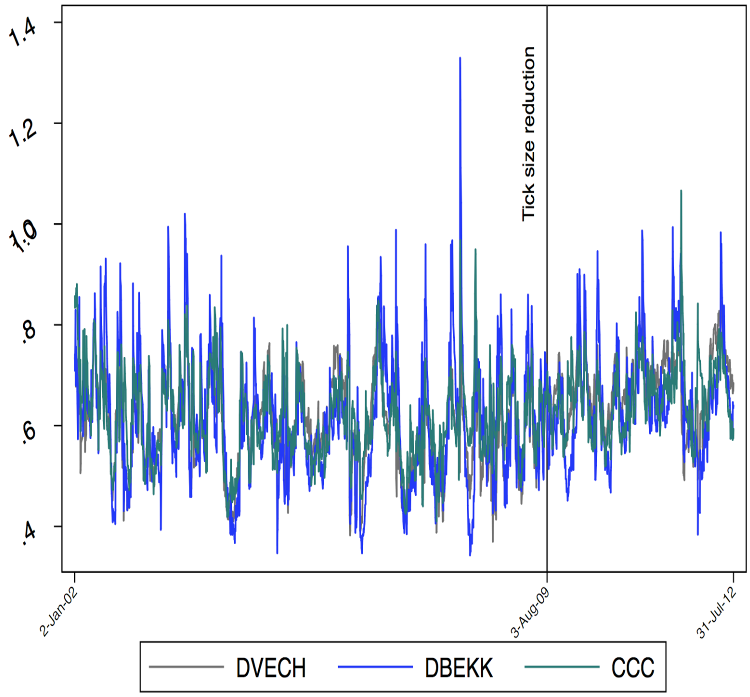

Fig. 6.2 : Time varying hedge ratios under the risk minimisation criterion

Table 6.5: Descriptive statistics for the estimated hedge ratios under risk minimisation criterion

	Whole in-sample			Pre-tick reduction			Post-tick reduction		
	DVECH	DBEKK	CCC	DVECH	DBEKK	CCC	DVECH	DBEKK	CCC
T	2602	2602	2602	1863	1863	1863	739	739	739
Mean	0.618	0.619	0.626	0.599	0.609	0.601	0.673	0.666	0.670
Std. Dev.	0.0944	0.120	0.0837	0.0822	0.0848	0.117	0.0968	0.0681	0.113
Minimum	0.363	0.343	0.411	0.379	0.408	0.340	0.0530	0.517	0.0221
Median	0.620	0.612	0.623	0.599	0.601	0.587	0.684	0.667	0.663
Maximum	0.953	1.329	1.066	0.972	1.015	1.388	0.888	1.061	1.043
Skewness	-0.0483	0.593	0.383	0.101	0.551	0.942	-1.205	0.694	-0.464
Kurtosis	2.560	4.183	3.642	3.028	3.671	5.735	7.534	5.479	8.034
J.Bera	22.0063	304.1505	108.2538	3.2344	856.1609	129.1394	811.8008	806.8055	248.4612
Probability	0.0000	0.0000	0.0000	0.1984	0.0000	0.0000	0.0000	0.0000	0.0000
ADF (5) [a]	-8.1430	-9.5130	-9.0350	-7.986	-8.7510	-8.7560	-5.1410	-6.6490	-4.9000
PP (5) [a]	-8.6600	-10.3390	-10.0730	-9.091	-9.5270	-9.7630	-6.7520	-7.0910	-5.6470

[a] Critical values 1% from Mackinnon (1990) for ADF and PP tests with trend and intercept is -3.4342

Table 6.6: Descriptive statistics for the estimated hedge ratios under utility maximisation criterion*

	Whole in-sample			Pre-tick reduction			Post-tick reduction		
	DVECH	DBEKK	CCC	DVECH	DBEKK	CCC	DVECH	DBEKK	CCC
T	2,602	2,602	2,602	1,863	1,863	1,863	739	739	739
Mean	0.599	0.601	0.608	0.586	0.588	0.596	0.637	0.636	0.634
Std. Dev.	0.593	0.557	0.613	0.519	0.490	0.535	0.764	0.715	0.797
Minimum	-1.605	-1.474	-2.216	-1.244	-1.116	-1.542	-1.887	-1.677	-2.218
Maximum	3.918	3.881	4.173	3.164	3.291	3.274	4.377	4.227	4.637
Skewness	0.549	0.492	0.552	0.418	0.385	0.417	0.629	0.583	0.723
Kurtosis	5.210	5.143	5.770	4.800	4.728	5.111	4.784	4.725	5.274
Median	0.571	0.577	0.579	0.575	0.574	0.580	0.573	0.572	0.574
J.Bera	660.1261	602.9476	963.9154	305.7749	277.9588	399.9337	146.7321	133.4235	223.6426
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ADF(5)[a]	-19.6720	-18.3920	-19.8180	-16.7580	-15.3750	-16.4940	-10.6950	-10.3610	-10.8840
PPP(5)[a]	-49.1000	-48.2480	-49.0260	-41.6120	-40.7120	-41.2510	-26.7230	-26.6140	-26.8400

* For simplicity the risk aversion parameter is assumed one.
[a] Critical values 1% from Mackinnon (1990) for ADF and PP tests with trend and intercept is -3.4342

6.4. In-sample and out-of-sample hedging performance

6.4.1. Variance reduction comparison

Table 6.7 reports the variance reduction of the hedged portfolio returns compared with those obtained for the unhedged portfolio for the in-sample sub-period. It is evident that the percentage variance reduction is higher post-tick period indicating more effective hedge. This is true regardless of strategy used to implement the hedge. With regard to the hedge model, the DVECH seems to produce slightly a better result. However, it is best to decide on which model is superior by looking at the model forecasting ability.

To achieve this, the coefficient estimates of all three models, from the post-tick period, were used to up-date H_t continuously throughout the 101 out-of-sample observations. Specifically, the hedge ratios were forecasted throughout the out-of-sample period by using estimates from the post-tick sub-period. The forecasted hedge ratios were then used to compute returns, and the variances for comparison with the unhedged position. The results are shown in Table 6.8. In this setting, the DBEKK model seems to be superior in comparison to the other two models.

Table 6.7: Variance reduction comparison for the in-sample sub-period

	No hedge	DVECH	DBEKK	CCC
Overall in-sample				
Mean of return	0.0335	0.0135	0.0127	0.0135
Variance of return	0.6522	0.2416	0.2551	0.2407
Percentage of variance reduction		-62.9561	-60.8842	-63.0901
Pre-tick period				
Mean of return	0.0291	0.0108	0.0107	0.0115
Variance of return	0.7725	0.2854	0.3048	0.2840
Percentage of variance reduction		-63.0563	-60.5456	-63.2369
Post-tick period				
Mean of return	0.0333	0.0212	0.0173	0.0190
Variance of return	0.6522	0.1287	0.1338	0.1321
Percentage of variance reduction		-80.2650	-79.4781	-79.7377

Table 6.8: Predictive performance of models under risk minimisation criterion
Summary of statistics of the actual spot returns, and returns of hedged portfolios computed using VECH, BEKK and CCC GARCH(1,1) in the out-of-sample periods.

Summary of statistics	Actual	DVECH	DBEKK	CCC
Mean of return	0.0342	0.0115	0.0165	0.0126
Median	0.0498	0.0070	0.0136	0.0085
Maximum	0.9019	0.8018	0.7677	0.7820
Minimum	-1.4127	-0.4867	-0.4925	-0.4763
Std. Dev.	0.4109	0.2214	0.2138	0.2187
Variance	0.1688	0.0490	0.0457	0.0478
Skewness	-0.7774	0.4979	0.5275	0.6314
Kurtosis	4.8215	4.1585	4.0215	4.1984
Jacque-Bera	24.1353	9.7245	8.9856	12.6286
Probability	0.0000	0.0077	0.0112	0.0018
ADF with intercept (5)	-21.1270	-3.8410	-3.7470	-3.8890
PP with intercept	-45.7000	-12.1280	-12.3030	-12.2980
T	101.0000	101.0000	101.0000	101.0000
Variance reduction		-0.7097	-0.7293	-0.7166

[a] Critical values 1% from Mackinnon (1990) for ADF and PP tests with trend and intercept is -3.4342

6.4.2. Utility maximisation comparison

The result for utility maximisation comparison is contained in Table 6.9. Again, the result suggests a more effective hedging following the tick size reduction given the higher expected utility. This implies that the move of lowering the tick size greatly benefit the market. Concerning the hedging strategy, the DVECH model seems to be superior in comparison to the other strategies both overall in-sample and out-of-sample.

Table 6.9: Hedging effectiveness - Utility and economic significance comparison[a]

	DVECH	DBEKK	CCC
Overall in sample	-0.4679	-0.4975	-0.4697
Pre-tick period	-0.5599	-0.5989	-0.5565
Post-tick period	-0.2362	-0.2503	-0.2453
Out-of-sample	-0.0810	-0.0759	-0.0807

Note: The risk aversion parameter is assumed 1
[a] The overall in sample period is from 2 January 2002 to 31 July 2012; the pre-tick period is from 2 January 2002 to 2 August 2009; the post-tick period is from 3 August 2009 to 31 July 2012. The remaining out-of-sample period runs for the remaining 101 observations ending on 31 December 2012.

6.5. Summary of chapter

The conclusion whether change in market design changes favourably affect the equity market is rather controversial. Using bivariate GARCH(1,1) and daily returns of spot and futures, we show that the lowering of tick size in emerging Malaysian market enhanced the usefulness of the index futures as a price setting mechanism.

Similar finding is observed in Spanish, where Andani, Lafuente & Novales (2009) find the optimal hedge ratio gradually coming closer to one due to increased liquidity. This support the notion that as trading cost decreases and arbitrage is facillated by ETFs, the correlation between futures and spot return increases, and hence on hedging effectiveness (Alexander & Barbosa 2007).

CHAPTER 7

Summary, conclusions and limitations

This chapter concludes the study and discusses the main findings of the empirical works. The key contributions and implications of this study and some suggestions for further research are also discussed.

7.1. Introduction

Tick size is one of the most important design features of an exchange. It determines the minimum movement that financial instruments are allowed to change, and as such directly affects the size of the bid-ask spread, the difference in prices at which buyers and sellers are willing to trade. Tick size affects both market liquidity and price discovery. Price discovery refers to the ability of the market in finding the equilibrium price, while liquidity is defined as the ability to trade at the lowest trading costs.

Exchanges around the world set tick rules as a way to simplify and ease trading. On the one hand, if the tick is set too high, liquidity demanders may have to incur higher trading cost because the spread, which is the main component of trading cost, would never be lower than the size of the tick. Further, price discovery may be disrupted due to the fact that traders would not be able to trade near the equilibrium price i.e. they are forced to buy (sell) at higher (lower) than the equilibrium price.

On the other hand, if it is set too low, however, liquidity suppliers may incur higher cost of providing liquidity. In addition, it is easier for them to step in front of one another at order-driven exchanges. As a consequence, they may reduce their supply of liquidity. Further, price discovery may be delayed due to higher number of possible prices at which to trade. That is, lower tick may complicate negotiation process between buyers and sellers.

The optimal tick size, therefore, represents a trade-off: a wider tick promotes liquidity from limit order traders and market makers, but at the cost of a higher bid-ask spread i.e. higher trading costs for investors.

Over the past two decades or so, there is a trend for exchanges around the world to reduce the mandated tick size, the effect of which on market liquidity remained open for debate. In general, the finding is that reduction in tick results in lower bid-ask spread and depth, however the impact on trading volume is less inconclusive.

Further, there are also concerns that the lower tick size may weaken the relationship between the index futures and its underlying. The reason is that spot market liquidity affects the basis, defined as the deviation of spot and futures prices from the cost-of-carry model i.e. the mispricing.

If the lower tick size improves the liquidity and this in turn causes the basis to narrow down, the price discovery role and hedging effectiveness of the index futures should improve because the narrower basis positively affects these two functions of index futures (Garbade & Silber 1983).

However, there are possibilities that the basis may widen even if liquidity in the underlying market improves following tick reduction. First, the unexpected spot volume may not represents arbitrageurs' trades because there is a possibility that the lower tick may cause depth to decline making it difficult or infeasible for them to execute their trades.

Second, even if arbitrageurs are not adversely affected by the lowering of tick, the basis may widen if speculators trades exceed those of arbitrageurs' in the composition of the unexpected trading volume (Cummings & Frino 2011). This is likely to happen given the lower trading cost in the underlying market caused by the lower tick sizes (Bollen & Whaley 1998), especially so the stocks that make-up the underlying index are of higher market capitalisation where speculators are able to act on stock specific information (Sutcliffe 2006).

Exchanges would be interested to know what would be the outcome of a lower tick as this would assist exchanges in finding the optimal tick size, one that ensures liquidity and price discovery. In light of that, we investigate the introduction of lower tick sizes in emerging Malaysian market. The ticks were reduced on the 3 August 2009.

In Chapter 4, we examine the impact of the lower ticks on the liquidity of the 30 constituent stocks that make-up the FBM-KLCI spot index, and in turn on the inter-market relationship between FBM-FKLI index futures and its underlying. In Chapter 5 and 6, we examine the price discovery role and hedging effectiveness of the index futures, respectively. In the following section, a summary of our empirical analysis is presented.

7.2. Lower tick sizes, spot market liquidity and index futures' pricing efficiency

Our first study, in Chapter 4 demonstrates the impact of the ticks reduction on the spot index liquidity and in turn on the inter-market relationship between the spot and futures indices.

We find significantly higher trading volume for the constituent stocks following the tick reduction. This finding is justified given that these stocks are large and that their prices were previously constrained by the tick size (Chung et al. 2005). This may have enable investors to trade these stocks more efficiently due to higher expected reduction in spreads. As such, the lower tick seems to improve the liquidity of the 30 constituent stocks that make-up the FBM-KLCI spot index, in support of our hypothesis. This finding is consistent with Hsieh et al., (2008), where they find the tick reduction in Taiwanese Stock Exchange, a pure order-driven market, improves liquidity, especially for the higher-priced, larger capitalisation and actively traded stocks.

As expected, we also find evidence to suggest that the unexpected trading volume following the tick reduction represent trades that help in reducing the basis. This implies that arbitrageurs are not adversely affected by possible decline in market depth, especially so traders in Bursa Malaysia do not normally quote higher depth with higher tick. This also implies that the tick reduction does not causes the index market to incorporate information ahead of the futures. In other words, the introduction of the lower tick sizes facilitate traders to respond quicker to mispricing (Henker & Martens 2005) and incorporate stock specific information more efficiently (Roll et al. 2007).

To confirm this, in Chapter 5 we investigate the spot and futures' speed of adjustment towards equilibrium price, which allow as to gauge how quickly the basis or mispricing is eliminated in the markets.

7.3. The price discovery role and hedging effectiveness of the index futures

7.3.1. Price discovery role of the index futures

We examine whether the reduction in tick sizes improve the price discovery role of the index futures, defined as the ability of the market to incorporate information ahead of its underlying index. This is so given the inherent advantages of futures trading such as absence of short selling restrictions.

Specifically, we investigate the lead-lag relationship between futures and the spot by using the cross-correlation function. Next, we investigate the lead-lag relationship in terms of the speed at which both spot and futures prices revert to equilibrium level. The results show that the futures' lead over the spot weakens post-tick size reduction. This is justified by the fact that the spot returns revert to equilibrium level at a higher speed, indicating better incorporation of stock specific information. However, the index futures lead the spot both before and after the tick reduction, and that controlling for thin trading effects in the spot return series does not alter this conclusion. For robustness, we assess the long-term relationship between futures and spot returns using the vector error correction model (VECM). Following the tick reduction, we find evidence to suggest that the adjustment towards equiblirium is operating primarily through the adjustment of the spot prices rather than the futures prices. This is consistent with existing empirical evidence, which suggests that reduction in tick size improves the reliability of index futures as the bellwether instrument as it allows for better incorporation of stock specific information. For example, in Toronto Stock Exchange, Beaulieu, Ebrahim & Morgan (2003) suggest that tick reduction improves the price discovery role of TSE 35 index futures, which they attribute to the transaction cost hypothesis. The reason is that, the ability to trade the underlying stocks reduces the basis/mispricing (Alexander & Barbosa 2008) and thus improves the price discovery role of index futures (Garbade & Silber 1983). Taken together, these findings suggest that the reduction in tick sizes in emerging Malaysian market improves index futures price discovery role.

7.3.2. Hedging effectivenss of the index futures

In Chapter 6, we examine the hedging effectiveness of the index futures. Sutcliffe (2006) suggests that the size of the basis influence the hedging effectiveness of index futures. The reason is that hedging transforms price risk into basis risk (Jorion 2007). Likewise, a lower basis after the tick should improve the hedging effectiveness of the index futures.

First, we compute the optimal hedge ratios using three MGARCH models, namely; diagonal VECH, diagonal BEKK and Constant Conditional Correlation (CCC) using GARCH(1,1) specification. Consistent with our hypothesis, it is found that the estimated hedge ratios are significantly greater post-tick size reduction in comparison to pre-reduction period regardless of model used. This support the notion that as trading costs decreases and arbitrage is facilitated by ETFs, the correlation between futures and spot return increases (Alexander & Barbosa 2007). Similar finding is observed in Spanish, where Andani, Lafuente & Novales (2009) find the optimal hedge ratio gradually coming closer to one due to increased liquidity and maturation effect.

Next, the hedging effectiveness of these hedge ratios are compared before and after the tick reduction. As anticipated, the results suggest that hedging performance of the index futures significantly improved as indicated by the higher variance reduction and higher utility in the post-reduction period. Thus, the introduction of the lower tick sizes in emerging Malaysian market enhanced the effectiveness of FBM-FKLI index futures as a risk management tool.

Overall, our empirical analyses provide evidence that the lowering of tick sizes improve the liquidity of the constituent stocks, which in turn strengthened the relationship between the underlying index and its futures derivatives. Alternatively, the usefulness of the index futures as a price discovery tool and price-setting mechanism is enhanced by the higher liquidity caused by the lower tick size as it improves the pricing efficiency of the index futures. In conclusion then, the tick reduction in emerging Malaysian market improves market efficiency.

7.4. Contributions of the study

In the following paragraphs, we briefly discuss some of the important contributions of the study. This thesis investigates the impact of the introduction of lower tick on liquidity in an emerging pure order-driven market. This is important particularly since a lower tick may have larger impact on liquidity in a pure order-driven market. The reason is that the size of the tick determines the cost of obtaining order priority in limit order book. To the best of our knowledge, besides Chung, Kim & Kitsabunnarat (2005), there is no other studies that have investigated the relationship between tick size and liquidity in Malaysian market. Further, the impact of tick size reduction seems inevitable especially in a relatively less liquid emerging market where the liquidity might be strongly affected (Bekaert et al. 2007).

Another contribution of this study is that it also considers how likely the inter-market relationship between spot and futures are affected by the lower tick size. While most studies have considered only changes in expected trading volume, we consider the impact of the unexpected spot trading volume on the basis (mispricing), which allows us to glean the source of information arrival in the cash market (Cummings & Frino 2011). Our finding suggests that the cash market incorporates stock specific information better after the tick size reduction. Moreover, in investigating the lead-lag relationship between spot and futures, we use the speed of adjustment estimators (Theobald & Yallup 1998; Theobald & Yallup 2004; Poshakwale & Theobald 2004) which shows how quickly the futures' mispricing is eliminated.

Finally, we contribute to the literature by assessing the impact of tick size reduction on hedging effectiveness of index futures. We are unaware of any studies that have investigated this issue.

Given the importance of tick rules on the overall functioning of the capital markets, the findings of this study should be of interest to regulators, investors and academics alike. Perhaps, for example, Bursa Malaysia may use the information to better regulate the market. Likewise, investors may be better informed on the impact of a tick reduction on market efficiency. Definitely, the issue on what constitutes an optimal tick size presents an interesting and challenging avenue for researchers.

7.5. Policy implications

It is evident that the lowering of the tick sizes has positive impact on the overall functioning of the local equity market. We have seen that following the tick reduction, liquidity in the underlying market improves as indicated by the higher daily changes in trading volume. Further, the unexpected component of the trading volume seems to strengthen the inter-market relationship between spot and futures. Collectively, these suggest that the objective of lowering the tick size, that is to promote liquidity and enable price discovery has been achieved.

However, the commitment to find the optimal tick size is pivotal for the exchange to continuously improve its market quality, especially so for an emerging market like Malaysia. Currently, the tick sizes are set based on the stock price alone, whereby higher tick is assigned for higher price stocks. Bursa Malaysia may consider other characteristics in setting the optimal tick size. For example, the tick should be lower for actively traded stocks and higher for inactively traded stocks (Cordella & Foucault 1999). Stock volatility may also be incorporated in setting the optimal tick size amongst others (Ascioglu et al. 2010). Perhaps, the firms should be allowed to set their on tick size (Comerton-Forde & Rydge 2006). Conclusively, in order to further improve liquidity and price discovery, the exchange should continuously strive to attain the optimal tick size.

7.6. Limitations and suggestions for further the study

We have made every efforts to make our results as robust as possible. Nevertheless, the study does have some limitations.

One of the limitations is the unavailability of data on bid-ask spread and depth. In addition to examining the impact of tick reduction on volume, most previous studies also assess the impact on spread and depth (Pavabutr & Prangwattananon 2009). The availability of these data would certainly make our study more robust as it enables us to examine the impact of the tick reduction on numerous measures of market liquidity. However, we contemplate that using the spot index trading volume as a proxy for the index market liquidity is suffice in addressing the issues at hand, given that trading volume is a function of bid-ask spread and depth. That is, increased volume reflects increased overall liquidity (Lee et al. 1993).

The unavailability of high frequency data is another limitation that has constrained our analysis. With intra-day data, we would be able to address our research questions in a more precise manner. For example, we would be able to gauge the bi-directional relationship between liquidity and mispricing at a higher frequency, and hence more reliable results. Similarly, minute-to-minute lead-lag relationship between futures and spot returns could also be investigated using intra-day data.

Given the opportunities, we endeavour to obtain the above unavailable data by getting a research grant from the Government of Malaysia. With these data, we intend to not only revisit the issues addressed in this study but also to provide new evidence in particular to assess the long-term effect of the tick size reduction. It is important to assess the long-term of impact of the lower tick size because a report by Grant Thornton dated September 2012[44] suggest that the lower tick size in the US, currently \$0.01 for all stocks trading above \$1, undermines market quality as it contributes to risky trading behaviour.[45]

The risk of a "race to the bottom" whereby competing trading platforms provide venues for traders to trade in ever smaller tick. Consequently, all trading platforms adopt the lower tick, which leads to reduction in investor protection, and thus degrade market

[44] The report is accessible at http://www.sec.gov/info/smallbus/acsec/acsec-backgroundmaterials-090712-weild-article.pdf

[45] O'Hara, Saar & Zhong (2015) suggest that one-size-fits-all tick structure may no longer optimal for the US market.

quality. In fact it is suggested that the tick size be increased in order to create job formation and increase investors' confidence. We are unable to assess the long-term effect of the lower tick given that we use a very recent data set.

In addition, we intend to examine how different clientele i.e. type of traders are affected by the tick reduction. For example, retail investors may react differently to a lower tick in comparison to institutional investors due to the size of orders they may undertake (Pavabutr & Prangwattananon 2009). It would be interesting to investigate the long-run impact of the lower tick on market liquidity and the inter-market relationship between futures and spot by taking into account the type of traders.

We also note that a successor of the CMP1 known as Capital Market Masterplan two (CMP2) was launched on the 12 April 2011. Similar to CMP1, one of the focuses in CMP2 is to further improve stock market liquidity. Although, the reduction seems to improve liquidity in the underlying market, it is still relatively lower in comparison to other markets in the region. For example, the regional turnover velocity in 2010 for Malaysia is 32.1%, while it is 94.5% in Thailand (Securities Commission of Malaysia 2011).

Therefore, the uncertainty concerning the long-run effect of the lower tick sizes and the on-going initiatives taken by the regulator in improving liquidity and price discovery present an interesting avenue for further research.

Appendix

Appendix 1: Tick size standards around the world

Market	Currency	Stock price per share	Tick size	Relative tick size
Australia	AUD	< 0.10	0.001	≥0.10%
		0.10 to 0.50	0.005	5% to 1%
		> 0.50	0.01	≤2%
Austria	EUR	All shares	0.01	-
Austria . ATX stocks	EUR	< 10.00	0.001	≥0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	≤0.05%
Bahrain	BHD	All shares trading in BHD	0.001	-
		USD0.01 to USD0.50	USD0.005	50% to 1%
		> USD0.51	USD0.01	≤2%
Belgium	EUR	< 10.00	0.001	≥0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	≤0.05%
		Certain stocks > 10.00	0.005	≤0.05%
Brazil	BRL	All shares	0.01	-
Bulgaria	BGN	All shares	0.001	-
Canada	CAD	< 0.50	0.005	≥1%
		0.5	0.01	≤2%
Cyprus	EUR	< 3.00	0.01	≥0.33%
		3.00 to 59.98	0.02	0.67% to 0.03%
		60	0.05	≤0.08%
Czech Republic	CZK	< 200.00	0.01	≥0.01%
		200.00 to 999.9	0.1	0.05% to 0.01%
		1,000.00	1	≤0.10%
Denmark . OMX C20 stocks	DKK	< 0.50	0.0001	≥0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
		5.00 to 9.995	0.005	0.1% to 0.05%
		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.90	0.1	0.1% to 0.02%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00 to 9,995.00	5	0.1% to 0.05%
		10,000.00 to 49,990.00	10	0.1% to 0.02%
		≥ 50,000.00	50	≤0.10%
Egypt	EGP	All shares	0.01	-

*Tick size as a percentage of price per share
Source: Grant Thornton - Capital Market Series Report (September 2012)

Appendix 1: *Continued*

Market	Currency	Stock price per share	Tick size	Relative tick size
Finland	EUR	All shares	0.01	-
Finland . OMXH25 stocks	DKK	< 0.50	0.0001	≥0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
		5.00 to 9.995	0.005	0.1% to 0.05%
		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
France	EUR	< 10.00	0.001	≥0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	≤0.05%
		Certain stocks > 10.00	0.005	≤0.05%
Germany	EUR	< 10.00	0.001	≥0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	≤0.05%
Greece	EUR	< 1.00	0.001	≥0.10%
		1.00 to 2.99	0.01	1% to 0.33%
		3.00 to 59.98	0.02	0.67% to 0.03%
		60	0.05	≤0.08%
Hong Kong	HKD	0.25	0.001	≥0.40%
		0.255 to 0.50	0.005	1.96% to 1%
		0.51 to 10.00	0.01	1.96% to 0.1%
		10.02 to 20.00	0.02	0.2% to 0.1%
		20.05 to 100.00	0.05	0.25% to 0.05%
		100.10 to 200.00	0.1	0.1% to 0.05%
		200.20 to 500.00	0.2	0.1% to 0.04%
		500.50 to 1,000.00	0.5	0.1% to 0.05%
Hong Kong	HKD	1,001.00 to 2,000.00	1	0.1% to 0.05%
(continued)		2,002.00 to 5,000.00	2	0.1% to 0.04%
		5,005.00 to 9,995.00	5	0.1% to 0.05%
Hungary	HUF	Certain shares	1	-
		Certain shares	5	-
Hungary . BUX stocks	HUF	All shares	1	-
India	INR	All shares	0.05	-
Indonesia	IDR	< 200.00	1	. 0.5%
		200.00 to 495.00	5	2.5% to 1%
		500.00 to 1990.00	10	2% to 0.5%
		2,000.00 to 4,975.00	25	1.25% to 0.5%
		5,000.00	50	≤1%

*Tick size as a percentage of price per share
Source: Grant Thornton - Capital Market Series Report (September 2012)

Appendix 1: *Continued*

Market	Currency	Stock price per share	Tick size	Relative tick size
Ireland	EUR	All shares	0.001	-
Ireland . ISEQ 20 stocks	EUR	< 10.00	0.001	0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	0.05%
Israel	ILS	All shares	0.01	-
Italy	EUR	< 0.25	0.0001	0.04%
		0.25 to 0.9995	0.0005	0.2% to 0.05%
		1.00 to 1.999	0.001	0.1% to 0.05%
Japan	JPY	< 2,000.00	1	0.05%
		2,000.00 to 2,295.00	5	0.25% to 0.22%
		3,000.00 to 29,990.00	10	0.33% to 0.03%
		30,000.00 to 49,950.00	50	0.17% to 0.1%
		50,000.00 to 99,900.00	100	0.2% to 0.1%
		100,000.00 to 999,000.00	1,000	1% to 0.1%
		1,000,000.00 to 19,990,000.00	10,000	1% to 0.05%
		20,000,000.00 to 29,950,000.00	50,000	0.25% to 0.17%
		30,000,000.00	100,000	0.33%
Mexico	MXN	< 1,000,000,000.00	0.01	1 □~ 10-11
Netherlands	EUR	< 10.00	0.001	0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	0.05%
		Certain stocks > 10.00	0.005	0.05%
New Zealand	NZD	< 0.20	0.001	0.50%
		0.2	0.01	5%
Norway	NOK	< 0.50	0.0001	0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
		5.00 to 9.995	0.005	0.1% to 0.05%
		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.90	0.1	0.1% to 0.02%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00 to 9,995.00	5	0.1% to 0.05%
		10,000.00 to 49,990.00	10	0.1% to 0.02%
		50,000.00	50	0.10%

*Tick size as a percentage of price per share
Source: Grant Thornton - Capital Market Series Report (September 2012)

Appendix 1: *Continued*

Market	Currency	Stock price per share	Tick size	Relative tick size
Poland	PLN	< 50.00	0.01	0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.90	0.1	0.1% to 0.02%
		500	0.5	0.10%
Portugal	EUR	< 10.00	0.001	0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	0.05%
		Certain stocks > 10.00	0.005	0.05%
Qatar	QAR	All shares	0.01	-
Romania	RON	< 0.10	0.0001	. 0.1%
		0.10 to 0.499	0.001	1% to 0.2%
		0.50 to 0.995	0.005	1% to 0.5%
Saudi Arabia	SAR	25	0.05	0.20%
		25.10 to 50.00	0.1	0.4% to 0.2%
		50.25	0.25	0.50%
Singapore	SGD	< 1.00	0.005	0.50%
		1.00 to 2.99	0.01	1% to 0.33%
		3.00 to 4.98	0.02	0.67% to 0.4%
		5.00 to 9.95	0.05	1% to 0.5%
		10	0.1	1%
Spain	EUR	50	0.01	0.02%
		> 50.00	0.05	0.10%
		Certain stocks	0.005	-
Spain . IBEX35 and	EUR	< 10.00	0.001	0.01%
IBEX medium stocks		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100	0.05	0.05%
Sweden	SEK	< 0.50	0.0001	0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
Sweden	SEK	5.00 to 9.995	0.005	0.1% to 0.05%
(continued)		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.90	0.1	0.1% to 0.02%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00 to 9,995.00	5	0.1% to 0.05%
		10,000.00 to 49,990.00	10	0.1% to 0.02%
		50,000.00	50	0.10%

*Tick size as a percentage of price per share
Source: Grant Thornton - Capital Market Series Report (September 2012)

Appendix 1: *Continued*

Market	Currency	Stock price per share	Tick size	Relative tick size
Switzerland . Blue chip stocks	CHF	< 0.50	0.0001	0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
		5.00 to 9.995	0.005	0.1% to 0.05%
		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.9	0.1	0.1% to 0.02%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00 to 9,995.00	5	0.1% to 0.05%
		10,000.00	10	0.10%
Switzerland . Non-blue chip stocks	CHF	< 10.00	0.01	0.10%
		10.00 to 99.95	0.05	0.5% to 0.05%
		100.00 to 249.90	0.1	0.1% to 0.04%
		250.00 to 499.75	0.25	0.1% to 0.05%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00	5	0.10%
Switzerland . SMI expanded stocks	CHF	< 0.50	0.0001	0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
		5.00 to 9.995	0.005	0.1% to 0.05%
		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.9	0.1	0.1% to 0.02%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00 to 9,995.00	5	0.1% to 0.05%
		10,000.00 to 49,990.00	10	0.1% to 0.02%
		50,000.00	50	0.10%
Turkey	TRY	5	0.01	0.20%
		5.02 to 10.00	0.02	0.4% to 0.2%
		10.05 to 25.00	0.05	0.5% to 0.2%
		25.10 to 50.00	0.1	0.4% to 0.2%
		50.25 to 100.00	0.25	0.5% to 0.25%
UAE (Abu Dhabi)	AED	10	0.01	0.10%
		10.01 to 100.00	0.05	0.5% to 0.05%
		100.01	0.1	0.10%

*Tick size as a percentage of price per share
Source: Grant Thornton - Capital Market Series Report (September 2012)

Appendix 1: *Continued*

Market	Currency	Stock price per share	Tick size	Relative tick size
UAE (Dubai)	AED	0.99	0.001	0.10%
		1.00 to 9.99	0.01	1% to 0.1%
		10.00 to 99.95	0.05	0.5% to 0.05%
		100	0.1	0.10%
United Kingdom . AIM stocks	GBP	< 10.00	0.0001	0.00%
(GBP/USD/EUR)		10.00 to 99.99	0.01	0.1% to 0.01%
		100	0.25	0.25%
United Kingdom . AIM stocks	GBX	< 10.00	0.0001	0.00%
(GBX)		10	0.25	2.50%
United Kingdom . FTSE 100 stocks	GBP	< 1.00	0.0001	0.01%
		1.00 to 4.9995	0.0005	0.05% to 0.01%
		5.00 to 9.999	0.001	0.02% to 0.01%
		10.00 to 49.995	0.005	0.05% to 0.01%
		50.00 to 99.99	0.01	0.02% to 0.01%
		100.00 to 499.95	0.05	0.05% to 0.01%
		500.00 to 999.90	0.1	0.02% to 0.01%
		1,000.00 to 4,999.50	0.5	0.05% to 0.01%
		5,000.00 to 9,999.00	1	0.02% to 0.01%
		10,000.00	5	0.05%
United Kingdom . FTSE 250 stocks	GBP	< 0.50	0.0001	0.02%
		0.50 to 0.9995	0.0005	0.1% to 0.05%
		1.00 to 4.999	0.001	0.1% to 0.02%
		5.00 to 9.995	0.005	0.1% to 0.05%
		10.00 to 49.99	0.01	0.1% to 0.02%
		50.00 to 99.95	0.05	0.1% to 0.05%
		100.00 to 499.90	0.1	0.1% to 0.02%
		500.00 to 999.50	0.5	0.1% to 0.05%
		1,000.00 to 4,999.00	1	0.1% to 0.02%
		5,000.00 to 9,995.00	5	0.1% to 0.05%
		10,000.00 to 49,990.00	10	0.1% to 0.02%
		50,000.00	50	0.10%
United States	USD	< 1.00	0.0001	0.01%
		1	0.01	1%

*Tick size as a percentage of price per share
Source: Grant Thornton - Capital Market Series Report (September 2012).

Appendix 2: The recommendations of Capital Market Masterplan

Market Institutions	
1	A single Malaysian exchange should be established through the consolidation of all existing exchanges by 2002
2	MESDAQ should be merged with KLSE as part of the exchange consolidation process
3	The Malaysian exchange should demutualise and list on the stock market by 2003
4	The Malaysian exchange should implement a programme to enhance its value recognition both domestically and internationally
5	The Malaysian exchange should pursue appropriate strategic alliances internationally
6	A common trading platform across all exchange-traded products should be established following exchange consolidation
7	An integrated clearance and settlement system for all exchange-traded products should be established
8	A single clearance and settlement institution for all exchange-traded products should be created by 2002
9	The money settlement system should be directly linked with the capital market trading and clearing systems
10	The settlement cycle should be shortened to T+3 in line with international best practice
11	A global depository account for each investor will be established in the central depository
12	The SCANS clearing fee will be reduced from 0.05% to 0.04% with effect from 1 July 2001, subject to a maximum of RM200 per contract
13	The SCORE fee will be reduced in two stages to 0.005% and 0.0025% with effect from 1 September 2000 and 1 July 2001 respectively. Subsequently, SCORE fees will be reviewed further
14	The SC levy will be reduced to 0.015% from the present 0.02% with effect from 1 July 2001
15	Stamp duty should be capped at RM200 per contract for all trades on the KLSE and be further considered for eventual removal
16	Administrative procedures and rule-structures in relation to portfolio investments should be streamlined in order to reduce operational costs to investors
Equity Market	
17	A full disclosure-based framework for the offer and issuance of equity securities will be implemented in 2001
18	The involvement of multiple approving authorities in the fund-raising process should be further rationalised
19	A shelf-registration scheme for the issuance of equity securities will be introduced
20	The market for the provision of corporate advisory services will be further deregulated
21	Technological solutions that enhance the efficiency of the fund-raising process will be identified and implemented
22	Breadth of listings in the Malaysian equity market will be gradually widened to include listings of foreign companies
23	The introduction of Exchange Traded Funds will be allowed
24	Comprehensive measures to enhance MESDAQ's role as a fund-raising centre for high-growth companies will be implemented
25	The listing of technology incubators will be allowed in 2001
26	The promotion and development of the venture capital industry should be centrally co-ordinated

27	Venture capital companies will be granted exempt dealer status under the Securities Industry Act 1983
28	The establishment of venture capital trusts that can invest up to 100% in unquoted companies will be allowed
29	The SC will undertake a review of the tax framework for the venture capital industry in collaboration with the tax authorities, industry participants and the central co-ordinating agency for the industry
30	Joint investment programmes between the government and private sector venture capitalists should be increased to boost private sector participation in disbursing government funds for seed and start-up capital
31	The participation of local institutional investors in venture capital funds should be promoted
32	Greater foreign participation in the venture capital industry should be allowed
Bond Market	
33	A full disclosure-based framework for the issuance of corporate bonds will be implemented
34	A shelf-registration scheme for the issuance of corporate bonds will be introduced
35	The mandatory requirement for credit ratings on corporate bond issues will be removed
36	A framework for the issuance of asset-backed securities will be introduced
37	The existing taxation framework for Special Purpose Vehicles should be clarified to reflect economic substance, and the stamp duty and Real Property Gains Tax on transactions relating to the issuance of asset-backed securities should be removed to encourage asset securitisation
38	Liquidity in benchmark issues should be developed and established
39	A programme to issue Malaysian government securities (MGS) should be encouraged and promoted with a view to establishing them as the immediate benchmark securities for the Malaysian bond market
40	Regulated short selling of MGS and corporate bonds should be allowed
41	Non-financial institutions should be allowed to conduct the entire scope of repo activities
42	Markets in MGS futures and options should be established
43	Employees Provident Fund's (EPF) investment requirements should be eased to free up its "captive demand" for MGS
44	Access to trading on the over-the-counter market should be extended to a wider range of participants
45	A phased programme to encourage international financial institutions and multinational corporations to issue ringgit bonds should be considered
46	International ratings for domestic bond issuance will be allowed
47	A programme for the establishment of a centralised platform for the clearing and settlement of listed and unlisted bonds should be pursued
48	The participation of retail investors in the corporate bond market will be encouraged through the promotion of the establishment of bond funds
49	The tax framework should be reviewed to encourage issuance and investment in debt securities
Derivatives Market	
50	Restrictions on the participation of unit trust funds and closed-end funds in exchange-traded derivatives will be deregulated
51	Derivatives funds will be allowed to be established and offered to investors in 2001
52	Restrictions on the participation of local institutions, including EPF and insurance companies, in exchange-traded derivatives should be deregulated
53	KLOFFE and COMMEX should actively pursue the introduction of more derivative products

54	The process for the introduction of new domestic exchange-traded derivative products will be streamlined
55	Local futures market intermediaries will be allowed to trade approved international financial derivative products by end-2001
56	A new category of International Members with full derivatives trading and broking rights will be allowed by 2002
57	Equity ownership requirements of futures broking firms will be liberalised to allow foreign majority ownership by 2003
58	Foreign Direct Clearing Memberships will be allowed to be established within MDCH by 2002
59	The SC will introduce guidelines for Introducing Brokers by end-2001
60	The futures broking commission rate will be fully negotiable by 1 January 2002
61	The futures clearing and exchange trading fees will be reviewed by 1 January 2002
62	The commission sharing structure between futures brokers and their representatives will be fully negotiable in 2002
63	Recognised foreign exchanges will be allowed to place remote access terminals with Malaysian futures brokers in return for reciprocal remote access arrangements by 2002
64	Regulated short selling and securities borrowing and lending activities should be re-introduced by 2002
Islamic Capital Market	
65	Efforts to introduce more competitive and innovative Islamic financial products and services will be actively pursued
66	Efforts to introduce and promote a wider range of Islamic collective investment schemes will be facilitated
67	Investment restrictions for the Takaful industry should be further liberalised to facilitate greater mobilisation of Takaful funds into the Islamic capital market
68	Efforts to mobilise untapped Islamic assets through securitisation should be pursued
69	Efforts to increase the pool of Islamic capital market expertise through training and education will be enhanced
70	A single Syariah Advisory Council should be established for the Islamic financial sector
71	A facilitative tax and legal framework should be established for the Islamic capital market
72	Efforts to develop an appropriate financial reporting framework for the Islamic capital market in collaboration with Malaysian Accounting Standards Board will be pursued
73	Increased efforts to enhance the awareness of Malaysia's Islamic capital market at the domestic and international levels will be pursued
74	Strategic alliances between Malaysia and other Islamic capital markets should be established
75	The government and government-related entities should consider issuing Islamic debt securities in the global market
76	The listing of Malaysian Islamic equity funds in international markets should be pursued
77	Incentives to encourage the entry of foreign intermediaries and professionals with expertise in Islamic capital market-related businesses should be provided
Stockbroking Industry	
78	Efforts to promote consolidation of the stockbroking industry will be pursued
79	A new category of full-service intermediaries to be known as Universal Brokers will be introduced
80	Branching restrictions on stockbroking companies will be deregulated

81	The scope of capital market services that may be offered by stockbroking companies will be widened
82	Stockbroking companies and their representatives will be allowed to offer a range of services under a single license
83	Stockbroking commission rates will be liberalised in two stages: Stage 1 - with effect from 1 September 2000, commission rates for all trades above RM100,000 will be fully negotiable while trades with contract values of RM100,000 and below are subject to a fixed rate of 0.75% Stage 2 - with effect from 1 July 2001, commission rates will be fully negotiable for all trades, subject to a cap of 0.70%
84	Commission sharing arrangements between remisiers and stockbroking companies will be fully negotiable in 2002
85	Foreign equity participation in domestic stockbroking companies will be liberalised in stages beginning from 2003
86	Measures to facilitate online trading will be introduced
87	Efforts to develop a standardised and centralised back-office system for the stockbroking industry will be facilitated
88	Efforts to further promote the use of information technology and e-commerce by intermediaries will be facilitated
89	The scope of activities carried out by remisiers should be expanded to a wider range of value-added capital market services, including financial planning
Investment Management	
90	A more market-based approach to regulation will be applied to the investment management industry
91	The process for introducing new investment management products will be streamlined
92	A uniform regulatory framework streamlining the licensing rules for the investment management industry will be introduced
93	The management of investment funds should be further deregulated to allow for greater international portfolio diversification
94	The SC will recognise industry self-regulation within the investment management industry, subject to appropriate criteria and under strong supervision, to complement the SC's regulatory function
95	EPF's investment guidelines should be liberalised to allow the adoption of the "prudent person" approach
96	EPF should further diversify the management of its funds by placing out a greater portion with external fund managers
97	The eligibility rules pertaining to the EPF's Members' Investment Scheme should be lowered over the longer term
98	Measures to facilitate the development of a private pensions industry will be actively pursued
99	The further outsourcing of the management of funds by insurance companies will be liberalised
100	Restrictions on the management of funds by Foreign Fund Management companies will be liberalised
101	Foreign ownership requirements will be liberalised to allow foreign majority ownershhip of unit trust management companies from 2003
102	The SC will examine the viability of implementing an investor compensation programme
103	Further tax incentives to encourage investments in collective investment schemes will be examined
104	Further efforts to promote investors' investment will be undertaken
105	Training and professional development needs of the Malaysian investment management industry will be facilitated

106	The development of the financial planning industry will be facilitated
107	The further development of the trust/custodial services industry will be promoted
Corporate Governance	
108	The recommendations contained in the Report on Corporate Governance will be effected in a timely and comprehensive manner
109	The SC will further facilitate efforts towards enhancing shareholder rights, especially those of minority shareholders, and broadening avenues for private enforcement of these rights
110	Minority shareholders' rights in respect of related party transactions will be further strengthened
111	Public listed companies will be required to provide appropriate shareholder value disclosures for securities issuance, restructuring, take- overs and merger exercises
112	A set of principles, best practices and standards will be developed to encourage institutional investor activism in corporate governance and the promotion of shareholder value recognition
113	The SC will strongly support the efforts of Badan Pengawas Pemegang Saham Minoriti Berhad in promoting shareholder activism in Malaysia
114	The SC will work with relevant industry bodies in enhancing the quality and independence of auditors of public listed companies
115	The SC will encourage the improvement of channels of communication between companies and their shareholders
116	The SC and KLSE will initiate further measures to promote timely, comprehensive and regular dissemination of material and relevant company information to shareholders
117	Efforts to further enhance disclosures in annual reports by public listed companies will be examined
Regulatory Framework	
118	The SC will put in place a comprehensive programme that will gradually implement a system of market-based regulation across all segments of the capital market
119	The SC will maintain the existing regulatory structure in relation to arrangements for the regulation of wholesale and retail markets
120	Relevant identified market institutions will be established as full front-line regulators to complement the SC's role in the regulation of capital markets
121	Appropriate industry associations will be identified and recognised as self- regulatory organisations to complement the SC's regulatory functions
122	Further efforts will be pursued to achieve regulatory parity in the treatment of all participants in the capital market through functional regulation
123	Efforts to create a single licensing regime and consolidation of securities and futures legislation will be pursued
124	Measures to eliminate market segmentation in respect of underwriting, corporate finance, asset management and brokerage services will be introduced
125	Cross-market surveillance as well as co-operation and co-ordination between regulatory authorities should be enhanced to strengthen market oversight, and to ensure the consistency and effective pursuit of regulatory objectives and priorities
126	Measures to enhance regulatory transparency, accountability and independence will be introduced
127	Measures will be introduced to enhance processes and capabilities for effective enforcement
128	Measures will be taken to enhance the enforcement capacity of the SC
129	The regulatory framework will be enhanced to provide for appropriate mechanisms for systemic risk management

130	The SC will develop a regulatory framework for the implementation of electronic commerce in the capital market
131	The SC will introduce measures to improve the assessment of regulatory cost-effectiveness
132	A five-year review to monitor effectiveness of regulatory structure and framework will be conducted
133	A comprehensive review of the current tax framework relating to the capital market should be carried out
Technology and E-commerce	
134	Capital market regulation will be technology-neutral and facilitative of innovation
135	Access to the market's trading infrastructure will be enhanced
136	Regulatory issues relating to the primary market offering and secondary market trading of capital market products through electronic means will be clarified
137	End-to-end straight-through processing in the Malaysian capital market should be achieved, with appropriate linkages with international systems to be facilitated
138	The facilitation of electronic trade settlement through the integration of the technologies of the clearing and settlement system with the payment system will be examined
139	The development of online value-added services and innovations such as financial portals and financial hubs will be facilitated
140	Online trading of units in unit trust funds will be permitted
141	Surveillance and enforcement capabilities of online capital market activities will be enhanced
142	Training and education programmes for market institutions, market participants and investors on the use of technology and e-commerce will be enhanced
143	International standards of security, reliability and privacy will apply to technology infrastructure
Training and Education	
144	Training programmes to create highly skilled and flexible market professionals will be developed
145	A culture of continuous learning and skill enhancement will be encouraged through Continuing Professional Education programmes
146	Skills of regulators, including front-line regulators and self-regulatory organisations, will be strengthened
147	Efforts will be made to increase the availability of skilled graduates for the capital market through arrangements with universities in curriculum development
148	Licensing examinations for capital market professionals will be streamlined
149	Education, training and licensing examinations will be made more accessible
150	The skills, knowledge and competencies of Bumiputera intermediaries will be enhanced
151	Investor protection and education will be further promoted through awareness programmes
152	The SC will develop SIDC as a regional capital market training centre

Source: Securities commission of Malaysia

Appendix 3: New tick sizes for equity based exchange traded funds

Stock price (Ringgit Malaysia (RM))[a]	Old Tick Size (sen)	New Tick Size (sen)
Below 1.00	1	0.1
1.00 to 2.995	1	0.5
3.00 and above	1	1

Source: Bursa Malaysia Annual Report 2009
RM1 = 100sen ≈ £0.20
Note: For ETFs trading below RM1, the tick size was reduced from 1 sen to 0.1 sen, while for ETFs trading between RM1 and RM2.995 the tick size was reduced by half i.e. from 1 sen to 0.5 sen. No tick size change for ETFs trading above RM3.00.

Appendix 4: Summary statistics for daily debt market explanatory variables (%) for the whole sample period[a]

	I	*T*	*Q*
Levels			
T	2704	2704	2704
Mean	2.977	1.209	1.137
Std. Dev.	0.464	0.744	0.171
Minimum	2.03	-0.506	0.598
Maximum	3.647	2.695	2.032
First differences			
T	2703	2703	2703
Mean	0.0000784	-0.000195	-0.0001067
Std. Dev.	0.023	0.065	0.079
Minimum	-0.784	-0.604	-0.676
Maximum	0.307	0.738	0.587

[a] The whole sample period is from 2 January 2002 to 31 December 2012
I : Yield on overnight Kuala Lumpur Inter-Bank Offered Rate (KLIBOR).
T : Yield spread between the constant maturity 10-year Treasury bond and the overnight KLIBOR.
Q : Yield spread between Bank Negara Malaysia (BNM) Grade AAA 10-year Private Debt Securities (PDS) and the constant maturity 10-year Treasury bond.

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